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Makers against Covid-19: Face shields as the international solidarity KPI

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ABSTRACT

At the first signs of the Covid-19 pandemic, the uncertainty around the global stock of medical supplies sparked a response in the DIY communities around the world. In the case of Spain, a community called Coronavirus Makers (CVM) appeared to supply ventilators and personal protection equipment (PPE) to hospitals and people in need. This paper explores the evolution of this community-driven development, detailing the patterns proposed by members of the group acting as design experts to tackle different problems. More specifically, the paper uses face shields, the most produced PPE in Spain, as a boundary object to highlight the relationships between individuals, institutions, and companies. These objects of design, being devices for medical use, must overcome validation at the technical level. Authors will also explore some of the controversies surrounding the transfer of these products from horizontal innovation networks to traditional production companies.

Keywords: community-driven development, covid-19, horizontal innovation network, maker movement.

1. INTRODUCTION

During the first moments of the Spanish Covid-19 lockdown in mid-March 2020, members of the Spanish Maker community gathered around a Telegram channel to discuss the possibility of creating a minimal ventilator in anticipation of a lack of these medical devices at hospitals across the country (Borao, 2020). Soon enough, the group grew by thousands and recognised the impossibility of having everyone collaborate in the design of a single project. Participants reorganised into different Telegram channels aimed at building PPEs and other tools against the pandemic (García, 2020). When it comes to ventilators, dozens of groups around the world started developing open-source ones (Pearce, 2020). While ventilators are of uttermost importance, it can be argued that the most replicated design, and that has put the Maker community in the spotlight, is the face shield.

The Spanish DIY communities have a large societal outreach (Cuartielles & García, in Press) which could explain why thousands of people joined this attempt to collaboratively design medical devices and PPEs (Palao, 2020). Several of the initiators of the early Telegram channel were previously involved in Clone Wars, a Spanish branch of the RepRap open-source project. This paper tries to support the hypothesis that the Coronavirus Makers (CVM) movement is the result of the technologically enhanced social fabric of Spain which brought together existing DIY cultures with volunteers from other parts of society.

The paper focuses on the challenges faced with the distributed design, manufacturing, and delivery of PPEs during the first hundred days of the lockdown of the Spanish pandemic. Being locked at home got the community to utilise personal digital manufacturing techniques: 3D printers, and electronic prototyping tools. The ease of design and manufacture of face shields made them into the main contribution generated by the CVM movement.

The production and shipping of goods was not exempt from challenges. After some weeks there was a shortage of materials, there was no freedom of movement for people or goods, and the designs for PPEs and other devices were not validated by public authorities, what hindered their acceptance by medical institutions. Paradoxically, city councils, regional officials, as well local and national security forces helped with the distribution of the PPEs to hospitals. Other sources of trouble were the never-stopping innovation and the intellectual property of the designs. Added to the multiplicity of manufacturing sources, delayed the design validation through public bodies, decreasing the outreach of the design.

2. RESEARCH QUESTION

Our aim with this article is to communicate the learned lessons that can be extracted from the process of creation and distribution of face shields in Spain. In such case, our main research problem is: what can designers and makers learn from the community driven design of the face shield, considering it to be a boundary object and even an indicator for solidarity and collaboration?

From that initial question, two secondary questions follow: which strategies can designers apply to distributed manufacturing processes? How could policy makers support DIY designer efforts to confront future crisis?

3. METHODOLOGY AND LIMITATIONS

We, the authors of this paper, got engaged with CVM's movement from its conception. Our work implies mapping the Spanish DIY culture taking the role of the participatory activist researcher engaged in the conversation while documenting the actions (Chatterton, Fuller & Routledge 2007). Our position is no secret among the community participants. In any case, we have expressed this fact openly multiple times during our data collection phase within CVM. By producing this paper, we are stepping back and temporarily taking the role of the observer. It is, however, hard for us to write about our participation in third person and have chosen the less-conventional narrator's voice for our writing.

We were actively involved in CVM, where we created a public-yet-moderated online forum for people to collaborate. When it comes to our individual contributions, we invested most of our time performing tasks from the ad-hoc governance platform created for the movement. The average workday with CVM for us could include coordination assemblies, funding decision meetings, fundraising calls, or preparing internal documents for the movement. As researchers we would meet daily to summarise the latest events and keep each other up to date. We operated as design experts according to Manzini & Coad's definition (2015, p. 45).

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4. BACKGROUND

This article builds upon aspects from distributed innovation, and the understanding of the existing ecosystem around DIY cultures in Spain. This section explores these aspects to lay a foundation for a later reflection process.

4.1. Distributed innovation in communities of practice

The Maker Movement has been portrayed by the media as a community of entrepreneurs, inventors, and creators which use every tool at their disposal to convert their ideas into physical products. According to Dale Dougherty (2011), founder of Make Magazine: "All of us are makers" which is not that far from Manzini & Coad's "we are all designers" (2015, p. 30). In most cases, these makers are presented as individuals who share their inventions with others.

According to Von Hippel (2002), these "users/self-manufacturers" can also organize as part of a horizontal innovation network:

> "user-only innovation development, production, distribution and consumption networks can flourish when (1) at least some users have sufficient incentive to innovate, (2) at least some users have an incentive to voluntarily reveal their innovations, and (3) diffusion of innovations by users is low cost and can compete with commercial production and distribution. When only the first two conditions hold, we propose that a pattern of user innovation and trial will occur within user networks, followed by commercial manufacture and distribution of innovations that prove to be of general interest."

Von Hippel's view on networks departs from the traditional producer-innovation paradigm, focused on market needs and return on investment of research and development (R&D) costs. Free innovation processes focus on collaborative evaluation, replication, improvement and sharing the results among peers so the community can learn in a virtuous feedback loop (2016). Makers often produce devices for their own use or to give them away to others, without any further commercial interests.

Authors like Hess and Pipek (2012) have categorized these initiatives as community-driven development, exploring the pre-conditions for innovation transfers to happen between communities and companies. Compared to the individual approach of Von Hippel's free innovators (2016), Maker communities work in a distributed fashion, collaborating on the creation of new devices and services using online platforms. One of the main examples of these practices is the RepRap project, that encompasses the work of hundreds of volunteers from all over the world. Next section will describe the origin of the Spanish branch of the RepRap project.

4.2. Spanish DIY communities of practice – Clone Wars

During a 2009 workshop at Medialab Prado, Professor Adrian Bowyer introduced the RepRap project to a group of 3D Printer enthusiasts, including Juan González, a robotics teacher at Universidad Carlos III de Madrid (UC3M). Juan, together with colleagues and students, streamlined the production of robots for their courses through a pedagogical narrative where each student manufactured her own DIY 3D printer. This emergent 3D printing community adopted their name of Clone Wars. The rationale is that students would replicate (or clone) their colleague's printers to make their own.

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Juan González launched a video series, explaining how to assemble, setup, and operate 3D printers (González, 2012). Most printers within Clone Wars' genealogy could be traced back to the first 3D printer which was called "Madre," Spanish for mother. More than one thousand clones of printers were produced by cloning.

Clone Wars' participants gathered at events and conferences. They experimented with distributed mass manufacturing through a new format called El reto –Spanish for the challenge. It consisted in collaborative processes happening once a year open for anyone to join and produce one piece of a larger design (Penamaria, 2018). A later format, the 3DPrinterParty, originated in León (iLeón, 2016) is a yearly event that brings together 3D printing enthusiasts and their 3D printers under one roof.

Figure 1. Clone Wars 2019 Reto: Four-meter-tall statue of J.M. Amuedo, collaboratively produced from 3D, courtesy of J. M. Amoedo.

As years went by, we observed how Clone Wars' newcomers shifted interest from the building process of the machines to the possibilities offered by the printers and their software ecosystem. In words of Williams & Edge (1996), openness losses relevance in front of technological black-boxed solutions when users can do what they want (3D printing in this case). This relates to the idea of commodification of the experience of digital manufacturing and its outreach to the masses (Cuartielles Ruiz & García Sáez, in Press).

Looking at the case from the perspective of building artifacts aimed at protecting human lives, as CVM's PPEs intention was, does it really matter that they are produced in non-open machines?

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5. CORONAVIRUS MAKERS

CVM quickly reached 16.500 members. It self-organised through the Telegram social network. The community grouped around two main activities: R&D, and manufacturing. Figure 2 shows the way groups were presented on CVM's website by March 16th 2020 (Coronavirus Makers, 2020a) and their relative sizes on March 22nd, eight days after the beginning of the Spanish lockdown. Early research created during this period hints that 35% around of the respondents within CVM belonged to a Maker collective or institution before Covid-19 (Conde Melguizo, 2020).

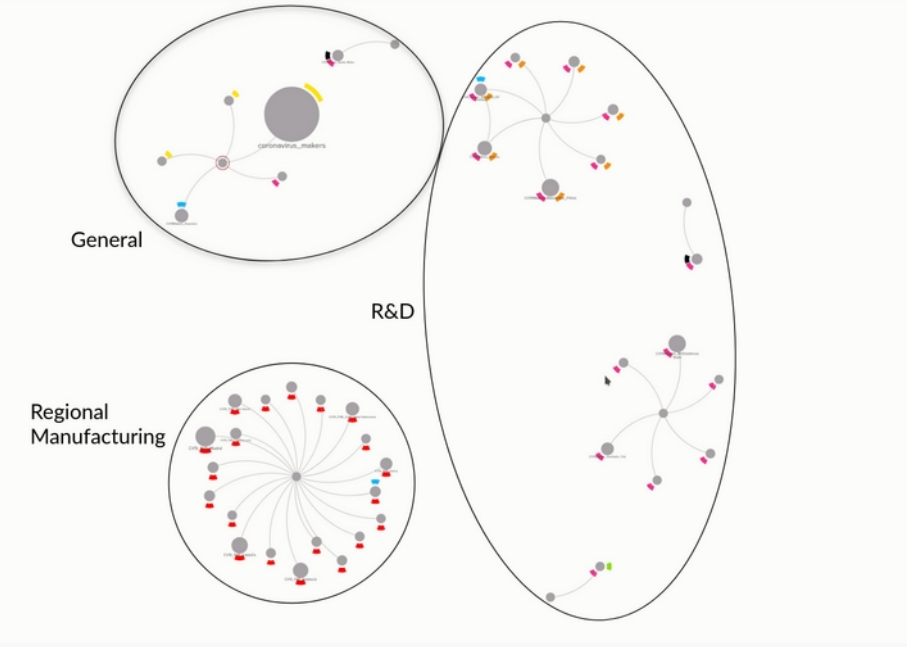

Figure 2. Emergent group configuration within CVM mapped using online tool Kumu.io from public data.

Complementing Telegram, a forum and a website were created. Realtime conversations happened on the messaging app while slower interactions happened on the forum. This dual platform configuration has been observed in other community-driven development instances (Hess & Pipek, 2012, p. 8).

Locality played a significant role in the movement's mode of operation. Raw materials came from donors all over the country, sent to regional groups that would then produce 3D printed PPEs. Community members with special permissions from the authorities picked up the manufactured goods and delivered them to hospitals, police stations, and other public bodies in need. Production groups were organised by region. Every group had their own specific Telegram channel to organize local production. Some groups even built their own logistic platforms, tailored to their needs. Working along the regional organisation units, the R&D group was also divided in smaller teams, each focused on designing specific products. A coordination group emerged, trying to couple the needs and capabilities of both R&D and the region-centric group.

During the peak of the lockdown, the regional groups had daily video conferences to discuss how to share resources, highlight the latest designs, or chat about the constant regulatory changes around medical products and devices. The R&D group met to evaluate whether to manufacture or not certain products based on the science at hand. We also set up a mechanism for accepting economic donations from companies and big donors through an external foundation to ensure there was no mischief in the handling of money.

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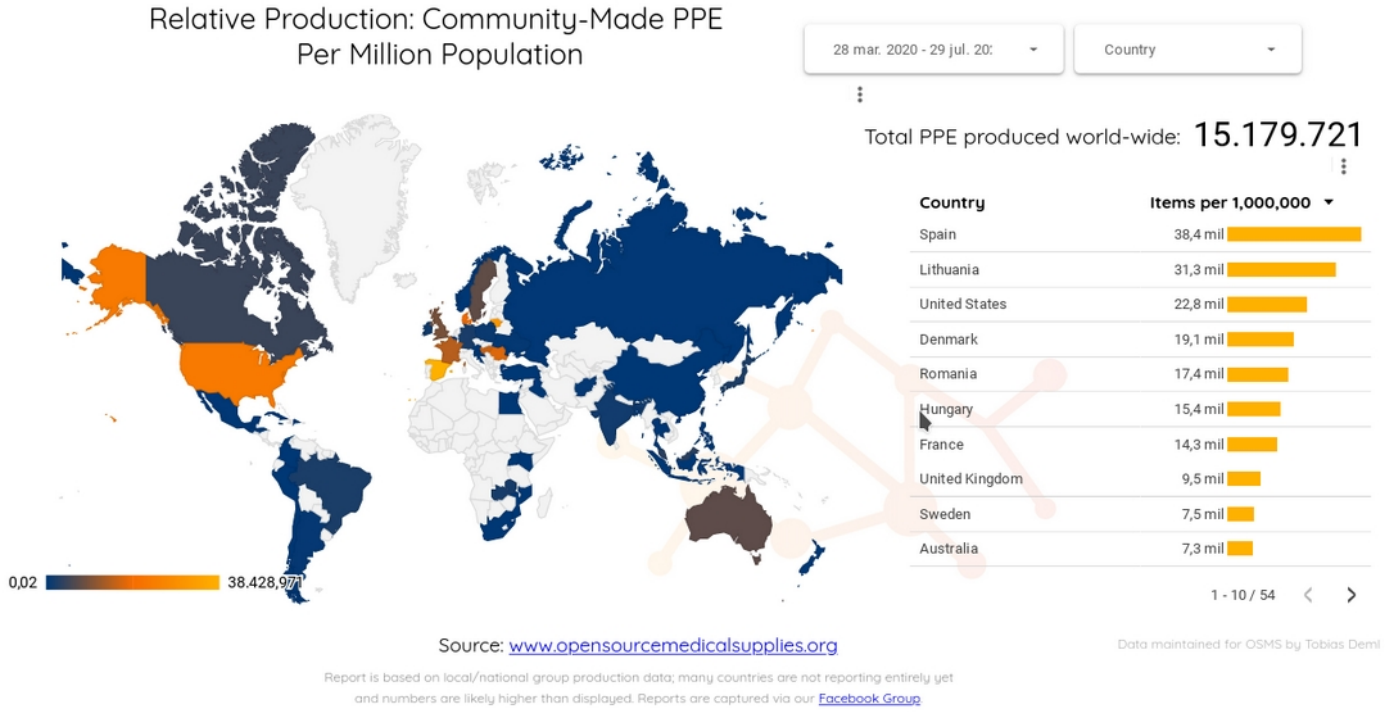

Figure 3. Open Source Medical Supplies - Relative Production: Community-Made PPE Per Million Population dashboard (Open Source Medical Supplies, 2020)

We do believe that it is this ad-hoc governance model that ensure the metrics in terms of produced (and delivered) PPEs in Spain. When comparing the data to any other country in the world, as seen in figure 3, Spain stands out as manufacturer of DIY PPEs.

6. OTHER VOLUNTEER-BASED INITIATIVES

The civic response to Covid-19 in Spain emerged from several groups, of which CVM was the largest one. Most of them had similar goals, but different means or mechanisms. In general, circumstances allowed Makers to shine, what validated the public image of the group amongst fellow citizens.

One of the most active groups was *COVIDWarriors* with more than 400 members, composed of professionals, senior managers, and patrons (COVIDWarriors, 2020). They got incorporated as a non-profit organisation on April 12th, 2020. COVIDWarriors' most important achievement is to secure funding to deploy 18 open source robots in Spanish hospitals to expand Covid-19 testing capabilities (Redacción Córdoba Buenas Noticias, 2020).

Other groups like *Frena la Curva* (2020) focused on social support and mutual aid via a geolocation platform. *Ayuda TIC* brings IT professionals together to offer pro-bono support to other initiatives, developing web services and common infrastructures. *Plataforma Makers CoVIDA contra Coronavirus*, also focused on 3D printed elements. They created 3D printed adapters for snorkel masks (Morán, 2020). Their similarities in name and goals to CVM caused a lot of confusion among newcomers and donors, with several media outlets misreferencing both groups (Compromiso Empresarial, 2020).

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7. THE FACE SHIELD: DISTRIBUTED DESIGN BY DESIGN

When CVM was getting ready to print parts for ventilators, a random spark put the focus on the production of face shields. One of the national coordinators of CVM got the request from a neighbouring nurse to create some sort of face protection to flying droplets from patients. As a result of that interaction, CVM identified the need of producing PPEs to supply healthcare professionals. He prototyped a first version to a face shield that was immediately tested on site. After sharing the design with the rest of CVM, in a matter of days, several groups were manufacturing and distributing face shields locally.

7.1. Description of a face shield

Face shields protect their wearers from flying particles of the Covid-19 virus which spread when people talk, breathe, and cough. The main protection element is a sheet of transparent and flexible plastic that is held in front of the carrier's face by means of a mechanical holder. This element has the triple function of keeping the shield straight, allowing breathing while performing any kind of daily operations with as much comfort as possible, and shielding the wearer from flying particles that could enter through the space between the forehead and the screen.

The DIY communities resorted into using CAD tools and 3D printers to produce the mechanical holders. Designs can be printed in as short as eight minutes by compromising features. The most replicated face shield is the so-called Hanoch design (2020). It considered the use of distributed digital manufacturing facilities, as well as the availability of materials, namely PLA filament for 3D printing and transparent overhead sheets.

In the early days of the pandemic, PPEs were considered single-use equipment. Over time, and due to the depletion of both plastic and overhead sheets across Spain, CVM included instructions for disinfection, reuse, and recycling with the PPEs. Some of these designs, however, did not remain static. Variations emerged based on specific validation requirements per region, materials' availability, or simply aesthetic customizations, challenging the idea of a universally valid design.

7.2. Validation

Validating a design opens the door to acceptance of the PPEs. We distinguish two types of validation: internal or external. CVM participants validated designs through discussions on chats and video conference prior to make it a de-facto standard for the community. On top of that, CVM created workflows for internal quality control of the distributed manufacturing processes. An outcome to a badly produced face shield could be the identification of a poorly tuned 3D printer. CVM groups focused in giving advice in fine tuning machines, a service also offered to newcomers. After collection from individual makers, face shields were subject to an additional inspection and disinfection before being delivered to hospitals.

External validation, on the other hand, is the official process that each one of the designs must pass either by the Ministry of Industry or the Spanish Agency of Medicines and Health Products (in Spanish, Agencia Española del Medicamento y Producto Sanitario - AEMPS). The unique designs must follow either path based on whether they will be used by medical professionals (Ministry of Industry), or by patients (AEMPS). As an example a ventilators being one of the most intrusive technologies to be used on patients, should overcome a

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complex test protocol designed by the AEMPS, while a face shield, being just a PPE, should be validated by the Ministry of Industry.

Given the exceptional circumstances the entire world is currently experiencing, a full set of regulations have been either relaxed or totally disregarded. Regarding the PPEs, the EU allowed importing non-CE labelled gear to accelerate the entry of new tools and protective equipment to the member countries. This applied to ventilators, masks, face shields, gloves, etc. This provoked an unexpected paradox: while there was the chance to buy suboptimal equipment, national producers had to be validated externally. As an outcome, hospital personnel would try to get any kind of protective gear — whether DIY-made or manufactured — while the hospital administration would ban the use of the 3D printed materials for lacking an official validation. At the same time, medics would fall sick and suffer personal stagnation while being forced to undergo risky work situations (Minder & Peltier, 2020; Amnesty International, 2020). CVM approached the problem by bringing all internally validated designs to pass whatever external validation process was required.

There is yet a distinction to make between regional and national validation. This is a specific problem for Spain, but it could apply to other countries. The national validation process requires testing the artifact against the existing norms at an officially appointed laboratory. To stimulate the production of the needed equipment, both the EU (International Organization for Standardization, 2020) and Spanish norms (Asociación Española de Normalización, 2020) were temporarily made public at no cost. The Hanoch face shield was designed long before the norms were made freely available to anyone, and so it was designed with no observance of the norms in mind. It just happened to be compliant at the time of testing.

Regional validation relates to the administrative division of Spain in autonomous units. While the medical competences as well as most of the security competences are handled at regional level, the state of alarm gave power to the central government to make some of the decisions (Marcos, 2020). This dual scenario complicated things for the maker community, which had no legal representation, when attempting to access any of the multiple national validation bodies. CVM decided to approach all the medical administrations in parallel.

This worked only partially. The Canary Islands' government issued a document validating the face shields presented to them by the local maker groups. In Cataluña, certain hospitals validated some of the PPEs for a subset of the medical system in the region (Part Taulí, 2020). The region of Madrid approved the use of DIY face shield and just three days later cancelled the previous order, prohibiting the use of face shields by medical professionals (Peinado, 2020).

This situation of uncertainty generated both anxiety among the medics and indignation among the members of the maker community. A final decision was made to force one of Hanoch's designs into a national validation process (Hemmerich, 2020), which completed successfully in April 2020 (Coronavirus Makers, 2020c). National validation ensured international recognition; the above-mentioned design was adopted in other countries like Argentina (Santandreu, 2020).

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Figure 4. Volunteers at fab lab Sant Cugat assemble several face shields models. There are at least three different variants of Hanoch face shield present. (Courtesy of fab lab Sant Cugat).

Unfortunately, the validation document came when most of the regional groups were calling off the action of the printing of face shields, after over a million pieces had been produced and delivered.

8. DISCUSSION AND CONCLUSIONS

Given the fieldwork synthesised above, we can conclude that this paper's research questions cannot be answered with a simple statement. The situation's extreme complexity and the speed at which events happened are our point of departure to formulate those questions. Therefore, in order to help designers, makers, and policy makers, we believe that the best way to respond is to produce a series of recommendations aimed at helping design experts grasp the power of distributed creation and manufacturing networks, and policy makers support the DIY movements of the future for them to make a difference in the crises to come. We are aware that we are not in the position of making strong generalisations of our learned lessons. However, we believe the following sections could help other designers and policy makers deal with similar situations in the future.

8.1. Recommendations for designers

Design researchers and experts should engage in the process at an early stage. There is no reason to believe that the high speed of events during the pandemic will be any different in the future. They should conceive mechanisms, whether automated or not, to synthesise the information. We used a slow platform (a forum) to slow down the high pace of a fast one (group chat over mobile devices). We did the work manually because the duration of the alarm scenario was uncertain and did not feel worth investing in developing anything. This leads to the recommendation of creating and documenting tools to monitor and synthesise public platforms to help future embryonic movements make informed decisions.

Communication, organisation, and governance are key. Once the techno-social network has been set up, the whole movement can adjust and shift focus. In the case of CVM, the network was formed around the production of ventilators. At some point, a large part of the network pivoted into the production of face shields. The initial momentum paid off, by having many groups within the community direct their efforts in different directions.

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Governance designers should assume different levels of involvement for individuals. In CVM there were thousands of participants 3D printing designs created by just a few tens of people, but all of them were considered at the same level within the movement. However, this could become the cause of arguments in terms of giving value to the different contributions. A question to ask oneself is whether it is more important to be the one creating the device, the one producing it or the one distributing. All are needed for the action to succeed.

A lax model for joining and leaving governance roles is needed to support these ever-changing structures At CVM we kept an agile approach to the forming members of the two groups dedicated to the coordination of the main actions of the group. People were excused from their duties out of exhaustion or sickness.

Care for others and oneself must be stated clearly as part of the aims of any design work. One of the most common issues was exacerbated stress. A volunteer group of psychologists offered their professional help to deal with the situation, in response to an open conversation about care and well-being in the CVM forum.

Knowledge transfer from the community of practice to the industrial fabric could generate unease among the Makers (Von Hippel, 2016). At CVM, the volunteers' efforts crashed against the reality of the industry in need to pay for materials and wages. We observed many conflicts around this topic among community members.

Design activities should focus on quick iterative loops, where feedback from those on field should be incorporated early on. There is also a need for domain experts to join the design groups. The design of face shields within CVM counted on having medical professionals involved in the testing process of early designs.

Bureaucracy should be considered only as a second step. Existing regulations for designing medical devices were left aside. Many times, they were unknown to the makers.

Do not assume existing designs as working elements. Even if there were several PPEs available as 3D designs most of them had never been tested under a clinical trial. As the CVM designs got iterated, previous models appeared repeatedly in the design sessions, slowing down the efforts to produce new designs that could comply with safety requirements and regulations. Proper versioning tools and documentation of decisions should be made as part of the process. Conflicts occurred due to not using any tools to document decisions and their rationale.

A common pattern emerges from previous recommendations, the existence of what we call weak commitments. We have observed how the creation of sets of strong rules, or strict modes or operation within CVM, either scared some participants away, or provoked conflicts within the movement. Therefore, we suggest creating room for weak commitments, allowing people to prioritize their wellbeing and personal needs in the first place.

8.2. Recommendations for policy makers

When sitting on the side of societal governance, we believe that the position taken by the UK in the creation of ventilators is a strong model to follow (Medicines and Healthcare Products Regulatory Agency, 2020). In this scenario, the government acted as intermediator between large scale manufacturers and those owning designs and processes to create more. Governments can empower those with the highest probability of success. In Spain, we –the

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researchers writing this article- in representation of CVM, along with COTEC Foundation, acted as middlemen between the AEMPS and over hundred inventors of ventilators at a two hours long meeting to raise any questions to the ad-hoc ventilator validation process the agency had just published (Cuartielles & García, 2020).

Policy makers should design pre-emptive responses to potential shortages of medical equipment. Basic manufacturing materials should also be considered. CVM worked for weeks thanks to the material donations from the makers themselves, but also from national companies that happened to have some stock. Eventually the stock ended world-wide.

Many European countries have never supported the DIY movements. Considering the role played by CVM, it is time to consider a larger implication from public institutions in the promotion of a societal interest in technology beyond innovation centres and universities. It would be interesting to promote transdisciplinary communities like the maker movement in schools and neighbourhoods to build a more capable techno-social fabric.

There is a need to promote public-private partnerships between small and medium enterprises (SMEs), local DIY communities, and public institutions to help the parties align in case of need. This should include clear workflows to go from a community design to a scaled up manufactured good assuring transparency and accountability at every step of the process. CVM improvised such a workflow for the face shields. SMEs in different regions ended up manufacturing injection moulded versions of the face shield designed by the CVM movement (Merca2.es, 2020). Yet another pattern could be the promotion of different solutions through competitions. An example of how this suggestion could be implemented comes from the above-mentioned case around the creation of ventilators in Spain. The COTEC Foundation curated a communication channel where many of the creators of those designs shared their status and disclosable research information (Innovadores, 2020).

8.3. Closing remarks

The above recommendations open a series of questions. From a knowledge production perspective, we cannot help asking ourselves whether a different governance model for the community would have produced a faster outcome. We would typically not consider the time dimension to be too critical when looking at distributed design, but being the case of Covid-19, time played a key role.

Face shields became a way to make visible the implication of different levels of society in the fight against the disease. Everyone wanted to be a part of this fight. From the person that bought a cheap 3D printer to multibillion companies like Nike (2020) or Apple (2020) that ended up producing face shields.

One could compare this situation with Manzini and Coad's (2015, p. 30) concept of anyone having the power to act in designer mode. Under pressing circumstances where we all are transformed into prisoners of our own homes, the uncertainty of the future and the fear for the possible consequences, made us all go into Maker-Designer mode. Everybody in the ecosystem contributed by their own means.

Finally, and reflecting upon our role as design experts, in what can be our largest contribution to the field, it is close to impossible to deal with the day-to-day of a movement by trying to apply design frameworks. We do believe that the only possible mode of operation is the one of the participatory activist researchers where design is made through

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the active participation in navigating the daily challenges of the movement. Planning is needed but it is hard to pursue when at a state of emergency. Design experts need to figure out how to balance their commitment and become part of the solution through collaboration and immersion.

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