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Networks of digital manufacturing of face shields and the Covid-19: design, maker culture and social mobilization

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ABSTRACT

This paper addresses the issue of the configuration of a network for the digital fabrication of personal protective equipment to fight the pandemic of COVID-19. The main aim is to highlight how creative and innovative design practices, based on digital fabrication, have contributed to combat the new coronavirus in Brazil, concerning the design, production and distribution of face shields. The paper is the result of both exploratory, descriptive and qualitative research. In addition to documentary data and revisiting design literature, this work sought to understand the network formation modus operandi for digital manufacture of face shields, based on examples carried out in every region of the country. In conclusion, it argued that these social mobilization networks are based on the assumptions of the maker culture and reveal the potential for an open, distributed and resilient design to face this contemporary and future crisis.

Keywords: Coronavirus (COVID-19), Design, Digital fabrication, Maker culture, Face shields.

1. INTRODUCTION

A few months ago, the world experienced the first devastating effects of the new coronavirus (SARS-CoV-2). The cause agent of COVID-19, first identified in Wuhan, in China, was recognized on December 31, 2019 (Brasil, 2020b). Within merely one month, on January 30, 2020, the outbreak of this disease established a “Public Health Emergency of International Importance” (Pan-American Health Organization, 2020). Abruptly, on March 11, 2020, COVID-19 was described by the World Health Organization (WHO) as a “pandemic” (Pan-American Health Organization, 2020). In Latin America, the virus rapidly spread and, in Brazil, the first case of the disease was registered on February 26, 2020 (Polato & Muraro, 2020).

Due to the pandemic, various and profound impacts - both individual and collective, ranging from local to global and of varied natures, such as psychological, social, economic, cultural and political - have been accounted for (Fundação Oswaldo Cruz, 2020). As leading preventive measures, social isolation and the interruption of non-essential activities have been adopted throughout the world (Campos, 2020). Several countries, states and cities have restricted the circulation of people, goods and merchandise, including even closing countries' borders (Sabino & Moura, 2020), imposing a new world order.

Given that scenario, many fields of human knowledge are being invited to rethink the current paradigms and propose emergency solutions to confront the spread of this pandemic, which differs from its predecessors, given the macro characteristics of globalization and the digital age. The Design field was also invited to reflect on present and future alternatives and solutions, which are already inserted in a broader discussion that considers, for instance, the diffusion of digital technologies, the emergence of the creative industry and the effective collaboration of users in decision-making processes (DESIS Network, [2018]).

All these issues are intrinsically connected to the maker culture (Mellis & Buechley, 2011; Ames et al., 2014), which accounts for emerging new design practices (Braida et al., 2018). This pandemic has been contributing to better explicitly the characteristics of the "fourth industrial revolution" (Schwab, 2016), in which "the digitization of society, the democratization of technology, the personalization of production and the gradual opening of the design practice (...) generate a new scenario in which the processes of creation, production and distribution of goods and services is undergoing profound changes" (DESIS Network, [2018]). Hence, bearing in mind the overlap between design and the maker culture, this paper addresses the following question: How the performance of designers and the development of digital manufacturing networks have contributed to the fight against the coronavirus pandemic in Brazil?

Because coronavirus causes respiratory infections, the Brazilian Ministry of Health (MH) recommended the use of personal protective equipment (PPE), such as masks and face shields, as a prevention strategy, among other measures (Monteiro et al., 2020). Consequently, by February 2020, Brazilians began to notice the lack of PPE and similar products in shops (Okumura & Chiara, 2020). In reality, neither in Brazil, nor in rest of the world, has the stock of industrial masks proved to be sufficient, demonstrating that the production chain was not prepared to meet such a demand. For instance, according to Davis (2020, p. 8), there is, in the United States, "a critical shortage of protective equipment for health workers". The militant nurses are making sure that all of them "understand the serious dangers created by faulty stocks of protective equipment, such as N95 face masks" (Davis, 2020, p. 8).

According to Gonzaga (2020), "among the COVID-19 outbreak, the Brazilian Medical Association (BMA) received, in one week, 2.5 thousand complaints about the lack of personal protective equipment (PPE) by doctors all over Brazil". Thus, it has been observed that "one of the great difficulties faced when fighting the spread of the new coronavirus is the lack of protective equipment for health professionals" (Albuquerque, 2020).

Due to the scarcity of PPE, worldwide collectives and digital manufacturing networks have begun to act in perfect harmony with the principles and assumptions of the maker culture. Involving the collaboration of different sectors and segments of society, constituting multidisciplinary teams (among which stand out engineers, designers, health professionals and independent makers), these groups are designing and producing valves for respirators, masks and, especially, face shields using 3D printers and laser cutters, on an emergence basis (Universidade Federal da Paraíba, 2020).

Aligned with most of the actions carried out in other countries since the advance of the pandemic, In Brazil, several universities and research institutions, governmental and non-governmental organizations, private initiative and independent citizens have also been cooperating to respond to the demand for PPE, especially those intended for health

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professionals. What emerges is the development of several networks, groups and collectives that quickly structured themselves to jointly propose solutions to this newer crisis, based on their know-how, founded on collaborative practices and open design.

Understanding the modus operandi of the organization and development of these groups is essential to reveal the strategic logic underlying the processes of social mobilization that has fostered actions involving digital manufacturing in the context of the pandemic. Therefore, the main objective of this paper is to highlight how creative and innovative practices of collaboration and open design within a generation of economically accessible products and services (based on digital manufacturing and the maker culture), have contributed to fight the new coronavirus in Brazil, especially with regard to the design, production and distribution of face shields.

2. METHODS

This paper is the result of both exploratory and descriptive, qualitative research. Concerning data collection, it comprises literature and documentary research. Primarily, information was collected on the internet, from television reports made available by broadcasters, from online newspaper reports or news published on the websites and social networks of Brazilian digital manufacturing collectives that have produced PPE to fight COVID-19.

Articles were collected between March 23 and April 23, 2020, when social distancing measures determined by federal, state and/or city governments were put to practice and the contamination curve had not yet reached its peak (Brasil, 2020a). The spatial scope was restricted to Brazil and the focus was on national coverage news concerning the pandemic. The selection included at least one initiative in each of the five Brazilian regions and considered the structured networks or collectives of digital fabrication. These collectives were found directly through Google search engine, using the following keywords: “face shield”, “digital manufacturing”, “coronavirus” and “COVID-19” and/or indirectly by surveying data from news reports.

The survey as a whole intended understanding what was the modus operandi of these groups’ development. More specifically, we can say that the question was: what is the modus operandi of the Design community on the fight against coronavirus pandemic in Brazil? To this end, the following categories were adopted to analyse networks (and/or collectives) regarding the creation, manufacturing and distribution of face shields (Figure 1):

a) origin and formation;

b) territorial spatialization;

c) structure and management;

d) ways of surveying the demand for face shields and attracting volunteers;

e) ways of financing the initiatives; and

f) design processes and equipment used.

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Figure 1. Analysis categories.

3. RESULTS

Throughout the world, many individuals called makers "have been organizing themselves to gather resources, tools and skills to quickly produce equipment that can help fight COVID-19" (Rigues & Rolfini, 2020). In Brazil, several initiatives are being organized to rapid prototyping and digital manufacture that seek to present solutions to combat the spread of the coronavirus. Table 1 presents some examples of Brazilian networks for the digital manufacture of face shields and their production.

Table 1: Brazilian digital manufacture networks in the combat of COVID-19

Order	Region	State	Face shield digital manufacture network	Last update Source	Quantity produced
01	Center-west	Federal District	Movimento Brasília Maior que COVID-19 https://www.instagram.com/bsbmaiorquecovid	May 11, 2020 Instagram	13,265
02	Northeast	Bahia	Face Shield For Life 3D https://www.faceshieldforlife3d.com/	April 27, 2020 Instagram	4,038
03	Northeast	Pernambuco	#CadaImpressaoConta http://e-nablebrasil.org/wp/cadaimpressaoconta	July 27, 2020* WhasApp	15,000
04	North	Amazonas	Liga Contra o Covid-19 Manaus https://www.facebook.com/covid19mao	July 23, 2020* Facebook	3,500
05	Southeast	Rio de Janeiro	SOS 3D COVID-19 https://www.sos3dcovid19.com.br	June 29, 2020 Instagram	23,032
06	Southeast	Minas Gerais	Juntos por Uberlândia https://www.juntosporuberlandia.com.br	July 24, 2020* Instagram	10,000
07	Southeast	Minas Gerais	Trem Maker Contra o COVID-19 https://tremmaker.com.br	July 2, 2020 Instagram	35,000
08	Southeast	São Paulo	Projeto Hígia https://www.projetohigia.com.br	July 24, 2020* Instagram	40,000
09	South	Paraná	Atitude 3D http://www.atitude3d.com.br	July 27, 2020* Website	37,287
10	South	Rio Grande do Sul	Brothers in Arms https://apoia.se/brothers	June 14, 2020 Website	73,640

Note: figures obtained from responses to contacts made by the authors of this article.

In the Northeast region, the project “Face Shield for Life 3D” stands out, launched on March 25, 2020, whose management group “is formed by researchers from the Bahian School of Medicine and Public Health (BAHIANA), State University of Bahia (UNEB), Federal University of Western Bahia (UFOB) and Youth Center for Science and Culture (CJCC)” (Face ..., 2020). The main objective of the project is to provide free face shields manufactured in 3D printers for health professionals in Bahia’s public health system who are working to fight COVID-19 (Face ..., 2020).

It is worthy of notice that, in this project, “production is collaborative and voluntary from makers with 3D printers, health professionals, researchers, professors, students and collaborators from various fields” (Face..., 2020). By March 28, 2020, the project had gathered 49 makers and, with 93 3D printers, 1,091 face shields had been produced, based on the Prusa Protective Face Shield - RC3 model (Face..., 2020). The project is crowdfunded, that is, collectively funded via donations collected throughout the internet. By March 29, 2020, the project had received funds from 547 donors and raised R$53.161,00 to purchase goods (EPI..., 2020).

In Pernambuco, “the movement #CadaImpressaoConta has already a vast network of makers, scientists, engineers, technology experts, health professionals and institutions working on the development of collaborative, sustainable solutions to this crisis” (Comunidade..., [2020]). Within the many participants of this movement, is e-NABLE Brasil, which “takes part in a global community that has a voluntary network dedicated to design, print, assemble and donate prostheses printed in 3D printers” (Bem-vindo..., 2020). On the e-NABLE Brasil website, there is a map registering the “public or private health agencies/units that provide essential services”, responsible for “logistics of receiving [face shield] donations, demand evaluation, assembly and delivery of devices” (Bem-vindo..., 2020). It is interesting to realize that the map spatializes the demands, allowing the closest makers to suppress the necessities of those in need, reducing costs and time with distribution.

In the Southeast, another group that has been working with additive manufacturing and laser cutting is the “SOS 3D COVID-19”, a collective formed by “students, professors, entrepreneurs, managers, doctors, lawyers, scientists, engineers from UFRJ and PUC- Rio” (SOS ..., 2020a). The objective of this group is "to help protect the medical teams of public and private hospitals", with "all the money and supplies collected being used exclusively for the donation" of products for these hospitals (SOS..., 2020b).

In the state of Minas Gerais, for example, in Uberlândia, the group “Juntos por Uberlândia” consists of companies, entities, public authorities and the community in general, which intend to “contribute to the improvement of conditions to fight coronavirus” (Juntos..., 2020). In Belo Horizonte, emerged the movement “Trem Maker Contra o COVID-19”, comprised of “engineers, designers, advertisers, programmers, doctors, digital manufacturing specialists” (Trem..., 2020). This “community of innovation labs” (Gonzaga, 2020) has made available, in their website, the files and a tutorial kit for the manufacture of face shields using 3D printers.

In São Paulo, the Project Hígia, linked to the group “Women in 3D printing Brazil”, is “formed by 130 women from various cities that work with 3D printing in research, product development and as a hobby”. This group has also been manufacturing face shields, with the collaboration of a network of approximately 1.300 printers (as of March 27, 2020) spread

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across national territory (Hígia..., 2020; Projeto..., 2020; Pontes & Potter, 2020). By March 30, 2020, this project had raised R$50,360.45 in online donations, from 290 donors.

Similarly, in the South region, the group "Atitude 3D" was assembled. They are a group of volunteers from Curitiba who produce face shields for doctors, nurses and other health professionals (Protetores..., 2020). Also in the state of Paraná, other digital manufacturing labs from universities have been producing this kind of equipment and state and local governments are engaged with startups and other entities that work with 3D printing (Sabardelotto, 2020).

In the state of Rio Grande do Sul, there are also digital manufacturing laboratories at the university collaborating with the group "Brothers in Arms", created by the "Pacto Alegre" movement. This movement aims to bring together "arm forces in favor of innovation for sustainable development and quality of life" in Porto Alegre (Pacto Alegre, 2020; Universidade do Vale do Rio dos Sinos, 2020). In the state of Santa Catarina, a group of employees coordinated by the PRONTO 3D network is also manufacturing face shields (Coronavírus ..., 2020).

Finally, initiatives for manufacture of face shields and goggle clips for healthcare professionals can also be found in the North and Center-West regions. Just like in other regions, the manufacture of PPE uses 3D printing and counts with both labs linked to universities and independent makers (Professores..., 2020; Universidade Federal do Acre, 2020). For instance, in the state of Amazonas, the "Liga Contra o Covid-19 Manaus" was created, which is a network of volunteers "consisting of makers, professors, students, entrepreneurs and healthcare and technology professionals, among others" (Rede..., 2020). In addition, in the Federal District, the "Movimento Brasília Maior que COVID-19" movement emerged as an independent group comprised of many volunteers from different backgrounds (Rios, 2020).

Figure 2 shows the location of the different groups on the map of Brazil.

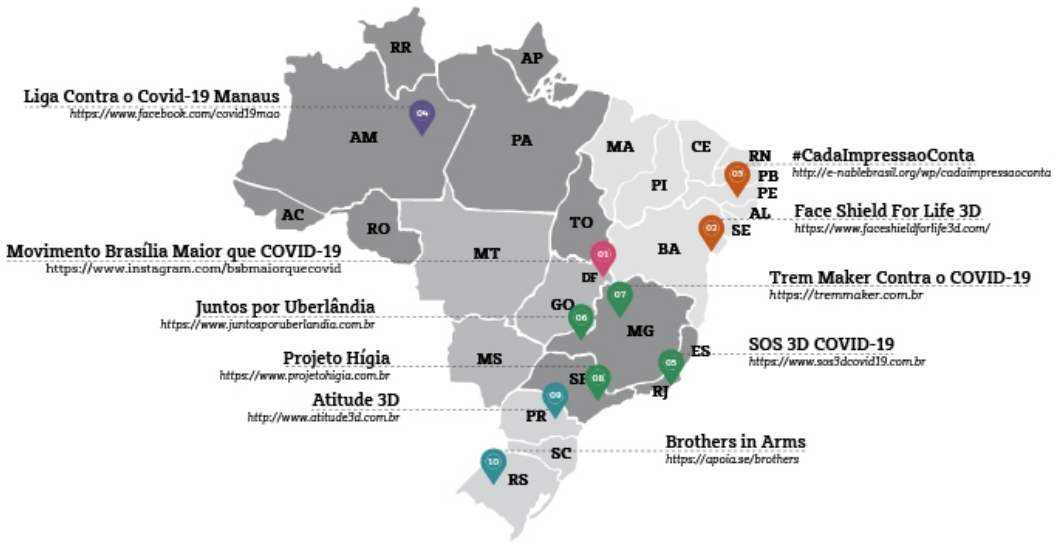

Figure 2. Networks and/or collectives in Brazil.

As demonstrated, the initiatives presented in this paper are spread across the regions of Brazil and have a common goal: to produce PPE, especially face shields, using digital manufacture, open design strategies and decentralized production, notably with the aid of additive technology (of 3D printers).

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In total approximately 1 million face shields have already been manufactured and distributed in Brazil. In addition to these groups presented in this article, there are several others. Protege BR (2020), a support network for health professionals against COVID-19, on July 27, 2020, accounted for 119 Brazilian initiatives that provided data on their donations, totaling 951,831 face shields.

4. DISCUSSION

When analyzing the constitution of digital manufacturing networks to combat the spread of coronavirus in Brazil, especially from the cases of face shields production, it has become clear that they are fully structured within the principles of the maker culture and the most contemporary precepts of the field of Design and those from creative industries. From the description of the initiatives of both preexisting collectives and groups that were configured because of an emergency situation, it is important to highlight some characteristics related to social mobilization and community participation (where individuals are imbued with a spirit of solidarity and cooperation), likewise the adoption of open and distributed design strategies.

It can be noted that those kinds of networks were developed throughout the country. According to Vasconcelos (2020), “this production and articulation has been made at national level because, with the spread of COVID-19, even the developed countries are unable to cope with the amount of PPE required and do not have logistics to meet the demand". Even though 3D printers, especially the elementary ones, were not designed for large-scale production, a considerable number of face shields have been produced since March 2020. It is worthy of notice that the production and distribution on a larger scale is related to the organization of networks themselves, which connect volunteers in different parts of the country.

Regarding the territorial spatialization of digital manufacturing networks that have been acting in the production of face shields, it is relevant to note that, although leaderships or group management may be situated at a specific spatiality, sometimes the networks expand to different locations and regions. Therefore, they are able to cross spatial boundaries due to the fact that they are organized around digital media and, although producing physical material, connections are digital. Consequently, these networks are based on dynamics that flow between local and global, concrete and digital.

It is worth mentioning that this way of organization is fully compatible with the guidelines and recommendations of social distancing and/or isolation, required and recommended by health authorities around the world. Since social distancing has been implemented as a health policy to flatten the curve of coronavirus pandemic in Brazil, the internet has become the major environment to support collectives of digital manufacture, who use social networks, apps, websites, mailing lists, among others, for communication and organization of their actions. Therefore, each maker, preserving social distancing, can make a contribution without having to gather in large agglomerations or in traditional factory spaces. This form of organization also overcomes the limitations of traditional production and distribution logistics centralized in large industries located at established points in the territory.

These networks structure and management follow an emerging logic, that is, they are bottom-up processes. In this way of management, there are no head managers to fully establish and plan all stages or to control production. In these networks, each volunteer

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assumes the role of a self-manager, not being obliged to meet productivity goals or act strictly within the parameters of a central administration. Instead there is a productive process strongly stimulated by ideological issues that involve social engagement fueled by a sense of community, empathy and solidarity, characteristics valued by contemporary design practices and the post-Fordist production method.

It is relevant to point out that, in general, networks of face shields manufacture, adopt a hybrid model of the different sectors of society, in non-hierarchical structures: (1) first sector: State; (2) second sector: private initiative; and (3) third sector: non-profit and non-governmental organizations. On a recurring basis, there are partnerships between public and private agencies, either to make production viable or to receive donated products.

Regarding the inquiry for the demand of face shields, the following dynamics were repeatedly observed: (1) some networks are created to meet a specific demand, previously identified, such as the demand of a hospital linked to a given institution, who is also part of the network; (2) some demand surveys are applied by digital forms, which can be filled in by different enterprises and institutions, within a certain spatiality or, else, located anywhere in the country. Similarly, to demands identification dynamics, the recruitment of volunteers and participants is also organized (1) based on their direct links with existing networks or institutions that foster the creation of a network or (2) based on voluntary membership from digital calls on social networks or e-mail contact lists, almost exclusively through digital means.

Concerning financing shares and costs for the production and distribution of PPE, the following triad is observed, as a general rule: (1) use of preexisting infrastructure: in order to avoid unnecessary costs, like the acquisition of new equipment, networks use the existing infrastructure of public or private institutions, or even resources from the volunteers themselves; (2) voluntary work: this type of work is the main labor force for the production and distribution of PPE, making product costs considerably low; (3) crowdfunding and donations: using the financial resources raised, manufacturing networks acquire raw materials and inputs, such as filament for printing, acetate (transparent plastic sheet), elastic, packaging for the accommodation of face shields (and later shipping of boxes), necessary for their production and distribution.

In relation to the design of face shields, the Prusa Protective Face Shield, developed by the Czech company Prusa Research, has served as an inspiration and is the model adopted by digital manufacturing networks in Brazil. This model of face shield, which has been widely used around the world, has been validated by the World Health Organization (WHO) and can be downloaded free of charge, since it is an open source project (Vasconcelos, 2020). In Brazil, the manufacture of such equipment without control by the National Health Surveillance Agency (ANVISA) is "exceptionally and temporarily" permitted, "due to the public health emergency" (Brasil, 2020c).

Figure 3 summarizes the modus operandi of the networks and/or collectives of manufacture of face shields in Brazil.

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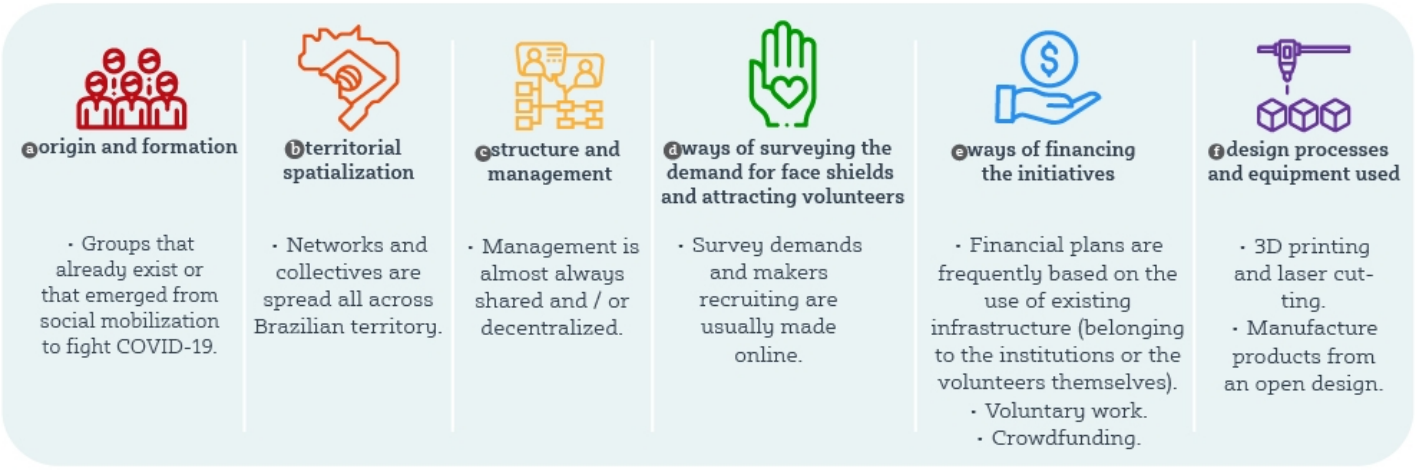

Figure 3. *Modus operandi* of the networks and/or collectives in Brazil.

5. FINAL CONSIDERATIONS

As we tried to demonstrate, the initiatives emerging in the scenario of the new coronavirus pandemic in Brazil, corroborating to others around the world, are based on contemporary design practices and are fully structured within the principles of the maker culture. It is relevant to recognize the articulating role of designers within the scope of transdisciplinary teams and within the engagement of independent makers, as well as the integration between universities or research centers and other sectors of society.

Summarily, considering the analytical categories adopted, it was verified that the networks and collectives: (a) are formed by groups that already exist or that emerged from social mobilization to fight COVID-19; (b) are spread all across Brazilian territory; (c) are generally managed by a shared or decentralized management; (d) survey demands and makers recruiting are usually made online; (e) financial plans are frequently based on the use of existing infrastructure (belonging to the institutions or the volunteers themselves), voluntary work and crowdfunding; (f) 3D printing and laser cutting are the mainly technologies used to manufacture products from an open design.

When analyzing the modus operandi of digital manufacturing networks in Brazil, partnerships between different sectors, the proposition of quick, technological, creative, innovative and sustainable responses are relevant to highlight, being the results of global thinking and local action strategies designated to solve new problems. Likewise, the sharing of information and, consequently, the democratization of knowledge (including design processes), collaborative work (mainly remote and decentralized), the hybridism between professionals and amateurs, between industrial production and the artisanal, are significant advances to respond to demands that more traditional production and distribution have not been able to meet yet.

Finally, the experiences mentioned in this article, considering the underlying logic in the development of social mobilization networks for the manufacture of face shields, reveal the potential for an open, distributed and resilient design that can be used to propose disruptive solutions for the present and future problems faced by contemporary society. They also shed light on new possibilities of contemplation in the field of Design itself, which, although often invisible, will continue to be an essential activity, especially to help (re)design a post-pandemic world.

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