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Lessons from Coronavirusmakers Community in Spain: 3D printing shield against COVID-19

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LESSONS FROM CORONAVIRUSMAKERS COMMUNITY IN SPAIN: 3D PRINTING SHIELD AGAINST COVID-19

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Abstract

Introducing the collective initiative of 3D printing enthusiasts and researchers, called Coronavirus Makers or “CoronaMakers”, during the hardest moments of the pandemic that took place in Spain from March to September of 2020. The article shows how this team, using communication and collaboration tools like telegram, and combining them with shared 3D printing blueprints and printers, helped distribute those printed tools to stop the impact of COVID-19 and help the community.

Key words

COVID-19, 3D PRINTING, OPEN KNOWLEDGE, CORONAVIRUS, MAKERS, OPEN DESIGN, SOCIAL DESIGN

Introduction

During the hardest moments of the COVID-19 pandemic in Spain, and after declaring the state of emergency at March 14th 2020 [1], all institutions in the country were closed and any collaborative work was halted.

The data that will be exposed in this article will show that, in the first months of the pandemic, access to protective masks and in general other medical equipment was scarce, and that situation motivated our team to try and use the tools in their hands to create 3D printable medical equipment. By combining collaborative tools like Telegram or WhatsApp, and sharing blueprints as well as printers, it was possible to create a virtual community of makers that successfully designed and printed a large number of prototypes, that opened the way to create a solution for those who had no access to these tools, to be able to print them at home, a true distributed micro-economy [2]. As other groups of people in Spain, in the UCJC, a team of researchers and volunteer students decided to create, combining their knowledge in 3D printing as well as the tools provided by the institution, new printable tools to increase access to those necessary medical equipment [3].

Eventually, the last question that was posed is, if it's possible to translate the knowledge acquired from this experience to other fields of production and consumption, using collaborative community tools to create a shared marketplace for blueprints allowing society to react faster and better to future crises, as well as creating new potential markets for modern distributed industry [4].

Initial environmental state

Chronological Regional expansion of the virus

In February 2020, the first official patient of COVID-19 in Spain was located on March 31th in La Gomera [5]. Beforehand, Italy -since January- was passing through a grave case of the pandemic. Most of the country was affected and required the government to quarantine almost all the regions [6]. Quickly the virus expanded to Spain, and by 14th of march the government decreed the state of emergency, prohibiting any movement in public spaces except for medical emergencies and for food acquisition [1].

Because of the speed in which the virus spread, it was impossible to prepare the country's infrastructure to withstand the demand for sanitary masks, so by decreeing the state of

emergency, the government ensured that they would have enough stock for the hospitals to operate and protect the medical personnel.

CoronaMakers take off

Facing this terrible odd, at one side finding ourselves confined to homes -all production and industrial activities, as well as educational and research activities- were immediately halted in the 14th of march, to allow only the necessary areas of production to operate. A group of volunteers (from their homes) decided to attempt and solve the lack of medical equipment, by using their knowledge in 3D printing, and the 3D printers, and proceed with designing face masks, and then printing them. The immediate idea was to create a quick solution to the lack of medical equipment.

To attain a working pattern, a methodology to use in different locations around the world and copy this method of work, we proceeded with creating a survey, which took place between the 12th of April and 7th of May 2020.

The research tool selected was an online survey. Online survey was chosen as main tool because three main reasons. Firstly, research was conducted between the 12th of April and 7th of May 2020 during the quarantine in Spain. Only online communications were allowed. during those days. Secondly, main communication channel of Coronamakers Community was a specific Telegram channel. Thirdly, the aim was to examine situation by describing factors associated, so survey was evaluated as the most accurate tool for a descriptive research. The questionnaire was designed based on the information we were gathering during our participant observation into Coronamakers social network and telegram channel. Different questions were emerging during this observation as: who are the people who is joining to this initiative? where they come from? how do they get to know this community? were they affiliated to any other 3D print group before the pandemic? etc. To solve these and other questions a specific questionnaire was designed and uploaded to a certain link in the Google Form Service. Usual recommendations about how to design a questionnaire has been taken in consideration: capital letters should be avoided; questions should be

numbered; clear instructions should be given; avoiding double barreled questions; double negatives; and leading or ambiguous questions; closed questions with pre-coded response options have been prioritizes over open one's questions [7] [8].

In order to approach to accurate potential subjects, survey was distributed using the Telegram communication channel, which was used by the Coronamakers community to coordinate the work. It was also distributed in other social networks channels, created by the Coronamakers team for broadcasting news, information as well as open calls for help in using and designing new medical equipment. As a covering letter was no suitable due the channel of communication and the exceptional quarantine situation, we included in any communication through telegram channel information about the aims of the study, people behind it, how to contact us and details about of how and why this community was selected. Also, we joined to the Telegram channel for answering the questions related to the study. Finally, we add a first paragraph in the online questionnaire: "Voluntary study on the maker collective that has mobilized to combat COVID-19. No personal data is requested, the information will only be used for scientific purposes and the results will be published openly".

The sampling selection technique was purposive sampling. This technique is carried on when a specific population is identified and then only its members are included in the survey. This is a non-random sampling technique, and it was based on three specific Coronamakers population features: the target population was clearly identified, the main channel of communication to them was also identified, and the population had some important homogenic characteristics -people who know how to print in 3D, who are currently printing protection equipment during the pandemic and who are in contact each other as a 3D printers community-. Purposive sampling is a valid sampling technique defined in the main scientific literature about research with questionnaire studies [7] [9] [10]

We collected 110 valid responses which were used in our research analysis. In the following section we will present some of the results mentioned above. The complete collection of

results, with all the details can be reviewed in *Figshare* [11] and can be downloaded, analyzed and published openly as long as the author is mentioned and the citation is referenced.

Results and Analysis

Who are the Coronamakers?

From the survey we can identify a large majority of **male** responses in contrast to **female** responses. Female responses were only 19.09% of total survey responses.

<i>Gender</i>	<i>N</i>	<i>%</i>
<i>Male</i>	87	79.09%
<i>Female</i>	21	19.09%
<i>TOTAL</i>	110	100%

Table 1. Gender.

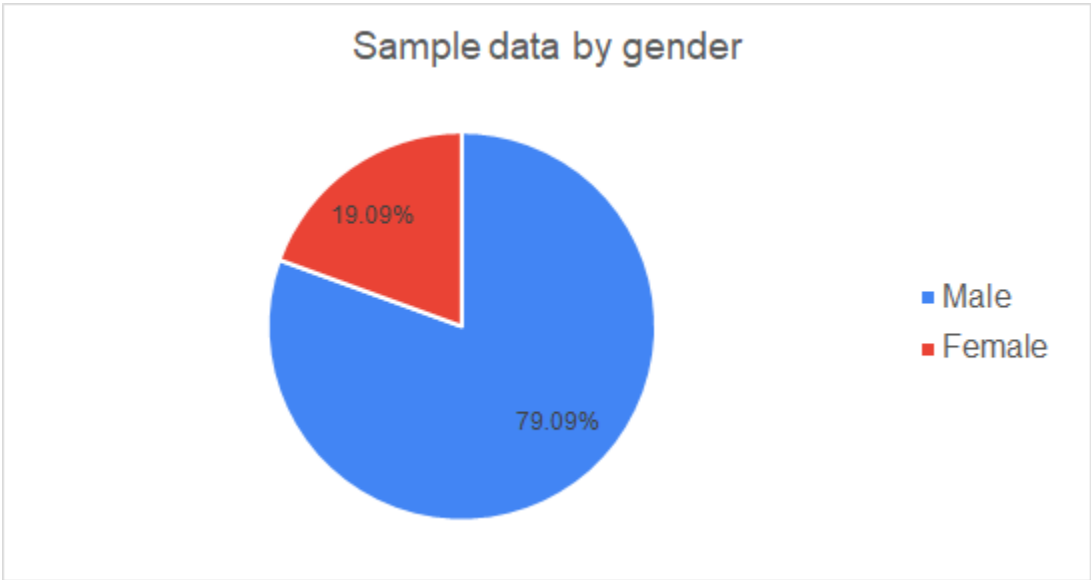


Fig 1. Gender.

Most of the participants in the campaign for 3D printing of medical equipment during the coronavirus crisis belong to a certain 3D printer community (86.36%). Only 13.65% considered their participation in the campaign as a personal and individual initiative.

	Sí	No	TOTAL
<i>Do you belong to a certain maker community?</i>	95	15	110
	86.36%	13.64%	100%

Table 2. Maker community.

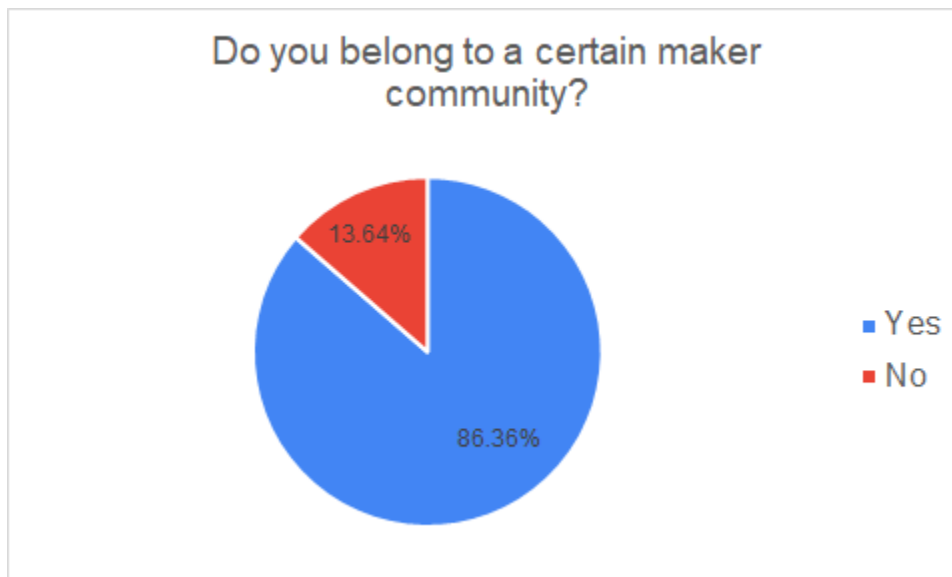


Fig 2. Maker community.

From those who considered themselves as part of a community, some of them already belonged to a group prior to the coronavirus crisis. Specifically, 22.11% belonged to a makers group in their State (Autonomous Community) and 34.74% of them belonged to a makers group in their city or region - it's important to mention that these answers were not exclusive.

Conclusively, we can confirm that a certain seed of Makers Community existed prior to the creation of the Coronamakers community. It's even so that a considerable number of the

surveyed participants showed their belonging to a makers community in their region (22.11%) in contrast to the new Coronamakers collective which represents 77.89% of those who consider themselves as part of a community.

To which community you feel you belong to?	N	%
<i>Coronavirus Makers</i>	74	77,89%
<i>A Makers Community in my State previous to the Crononavirus Crisis.</i>	21	22,11%
<i>A Makers Community in my city or local region before the Coronavirus Crisis.</i>	33	34,74%
<i>Other</i>	9	9,47%
TOTAL	95	100%

Table 3. Community you belong to.

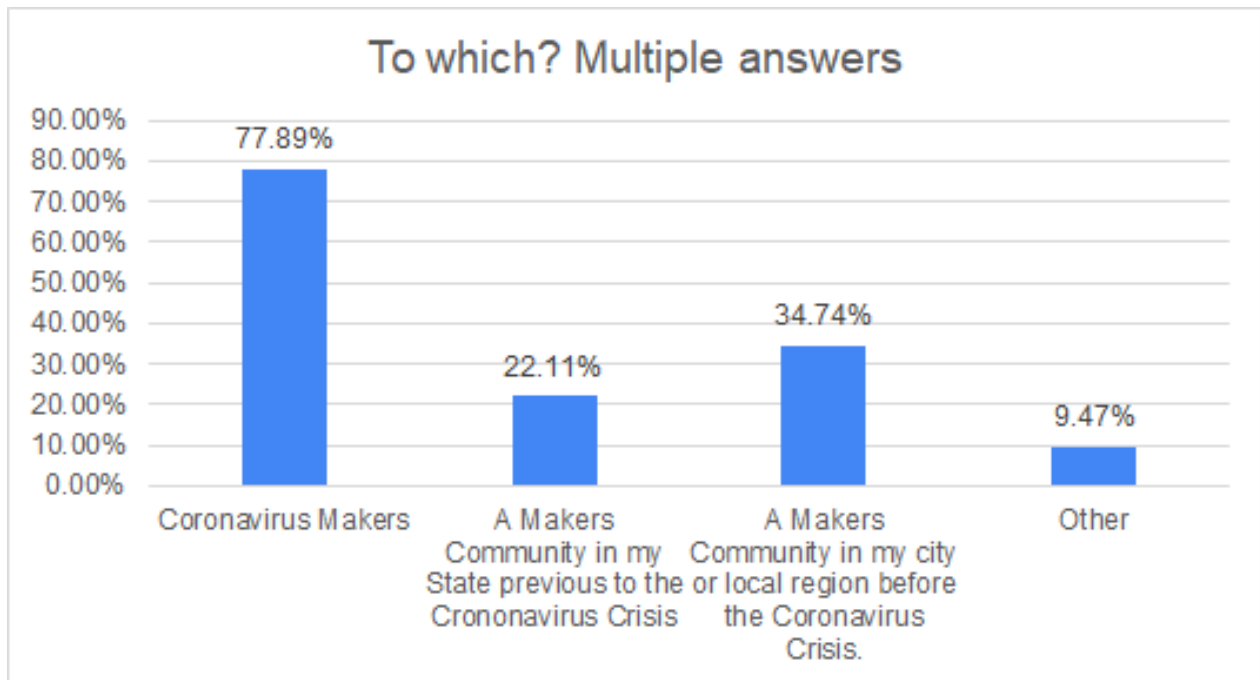


Fig. 3. Community you belong to.

Where was the medical equipment printed during the Coronavirus crisis?

In this study we can highlight a significant predominant answer. The majority printed their 3D medical equipment at home (87.39%).

Where are you printing during the Coronavirus crisis?

<i>At home. I have a 3D printer.</i>	97	87.39%
<i>At a friend's 3D printer.</i>	4	3.60%
<i>At a FabLab.</i>	0	0.00%
<i>At the University</i>	1	0.90%
<i>At school</i>	0	0.00%
<i>Other</i>	6	5.41%
<i>I stopped printing.</i>	6	5.41%
TOTAL	111	100%

Table 4. Where are you printing?

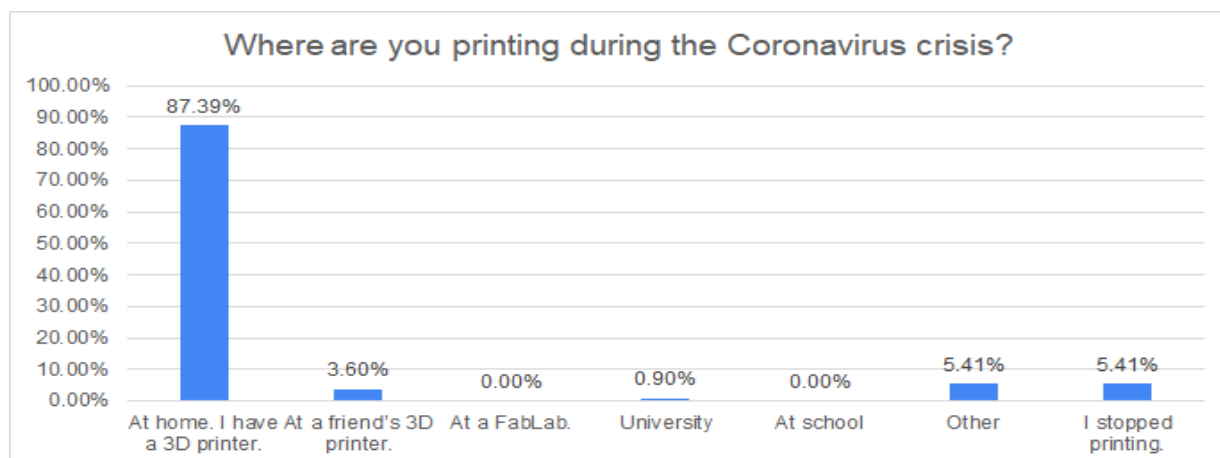


Fig 4. Where are you printing?

From the result we can see an overwhelming preference to a specific choice and it also may look as if the rest of options are practically irrelevant. Nevertheless, we can also extract some interesting conclusions from this data. First, we have compared these results with the ones obtained previous to the coronavirus crisis.

By adopting such comparison with the mentioned data, we can see a slight rise in the percentage of users which printed at home (87.39%) versus the data previous to the coronavirus (83.33%). It's a small variation which is to be expected as a result of confinement. It's much more significant the fall in people who printed at FabLab, universities, schools and other printing sections, 29.63% prior to the coronavirus crisis and 6.31% during the crisis.

It's also important to mention that not everyone decided to move their work to a different location, 5.41% have decided to stop printing as a whole, but yet they keep their link and activity in the community, as can be seen from their participation in the survey and their responses to such. In these specific cases we can observe that the feeling of belonging to the community goes further than just the activity of printing medical equipment during the pandemic.

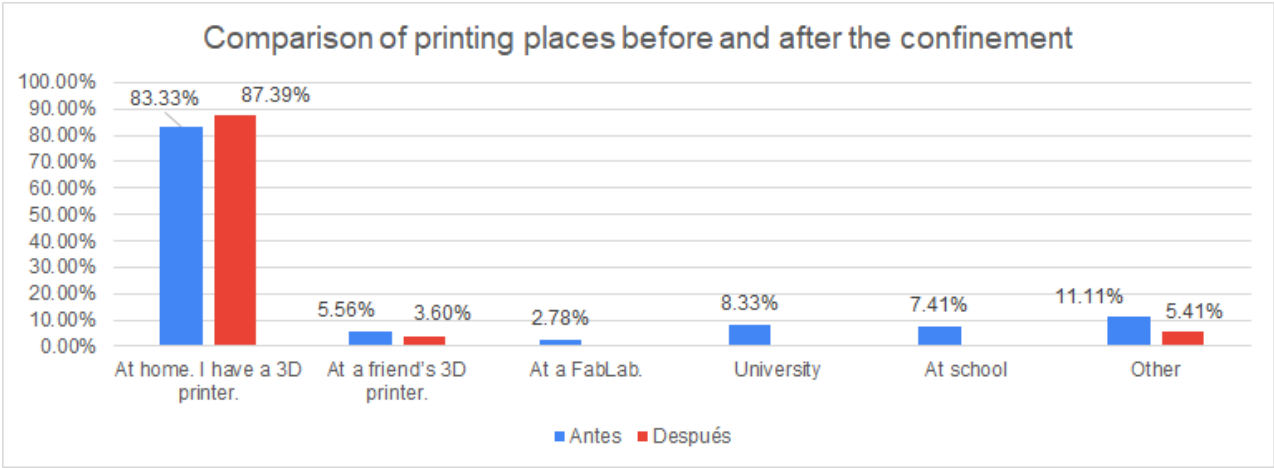


Fig 5. Comparison of printing places.

It also merits analyzing the percentages of those who decided to print in 3D printers of friends or other family members. In this case we may have thought that the percentage should have stayed the same as before the pandemic or even increased during the confinement, mainly because files can be sent digitally over the internet, yet we see a slight fall in this choice, which was already small, from 5.56% to 3.6%.

Which medical equipment were printed and how were they distributed?

Almost all makers who answered the questionnaires were printing medical equipment during the pandemic (92.7%). From those, 100% printed medical visors, resulting in the main medical equipment printed by the Coronamakers community. The rest of the equipment had a significant percentage but did not overcome the 50% barrier in the survey responses.

Did you print medical equipment to be donated during the pandemic?

Yes	102	92.7%
No	8	7.3%
TOTAL	110	100%

Table 5. Medical equipment to be donated.

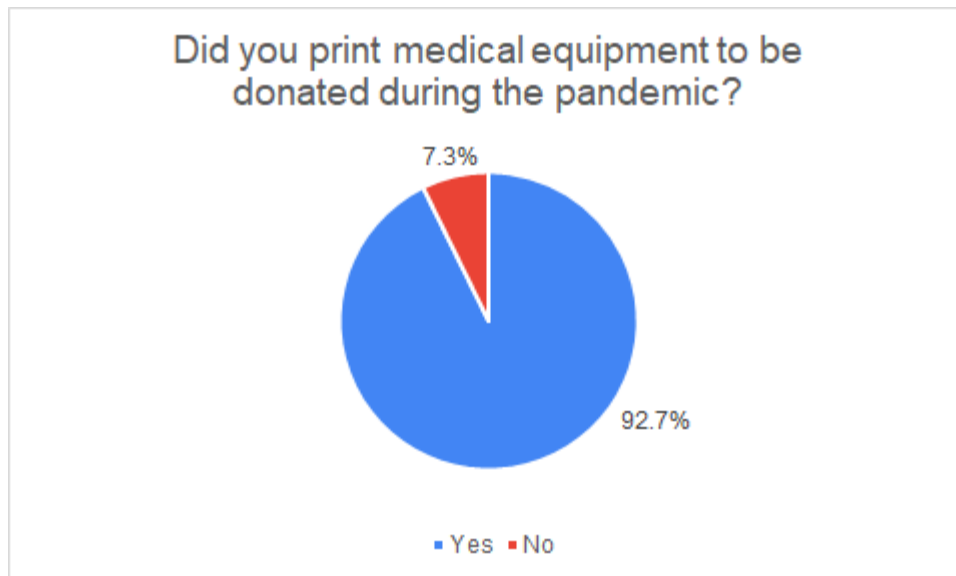


Fig. 6. Medical equipment to be donated.

What equipment did you print?

<i>Visors</i>	102	100.00%
<i>Other protective equipment</i>	44	43.14%
<i>Door opener, foot opener or similar</i>	33	32.35%
<i>Ear guard</i>	22	21.57%
<i>Respirators</i>	10	9.80%
<i>Other</i>	6	5.88%
TOTAL (N)	102	100%

Table 6. What equipment did you print?

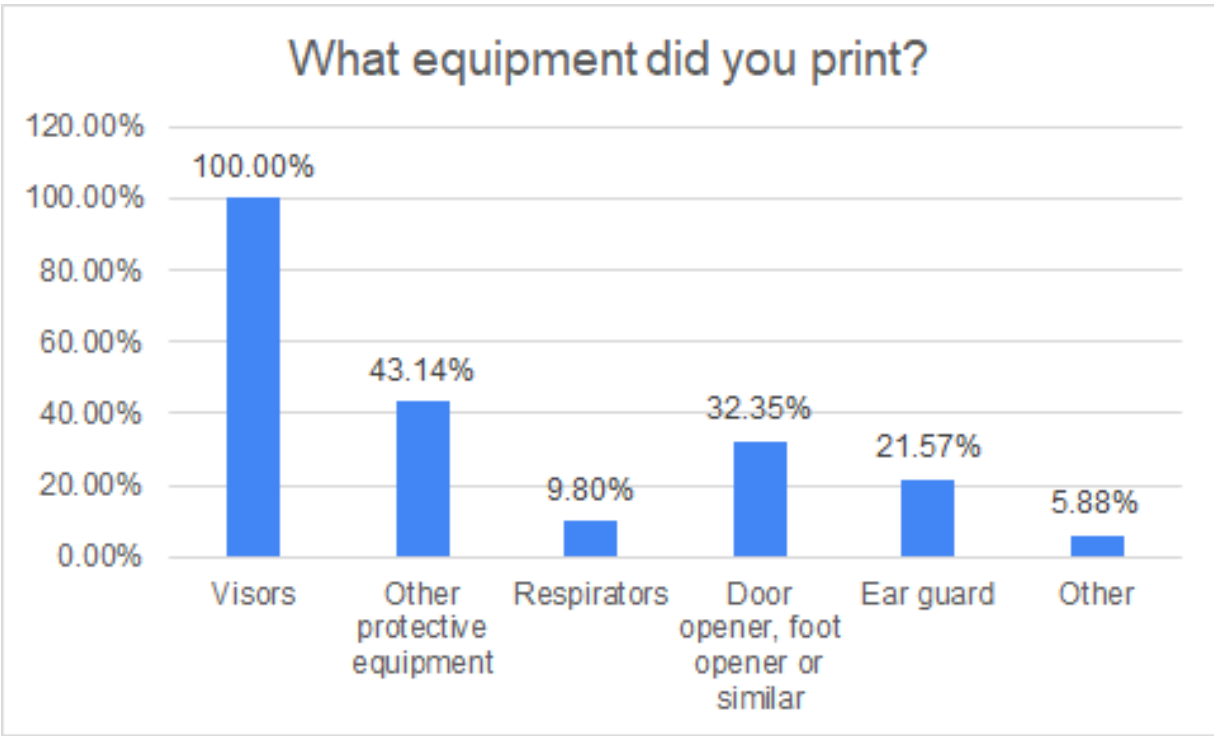


Fig. 7. What equipment did you print?

The next issue at hand was how did we get the products to their destination, taking in consideration the limitations imposed by the Royal Decree 463/2020, from the 14th of March, in which the state of emergency was declared in all the Spanish territory (BOE, 2020).

The organized volunteer groups was the most used option in this case (59.91%) for successfully solving the issue. Specifically, 9 of each 10 members of such volunteer groups (89.29%) referred to other volunteer makers groups rather than the Coronamakers group in their responses, like the Red Cross and other organized entities created prior to the pandemic.

It's important to mention the large number of surveyed members which delivered the printed medical equipment by themselves (30.91%), being this the second preferred option even though the existence of limited access to public spaces as could be seen during the confinement.

Yet we don't have information on how such deliveries took place, and we propose a future line of investigation in this matter. These same questions regarding the process that took place during the state of emergency by members that weren't officially organized and for which delivery took place by non organized volunteers (26.36%) also arose and are still to be studied in future work.

Nonetheless the state security forces, including police and *guardia civil* were selected in 30% of the cases as an option to deliver printed equipment, being this only the third most selected option in the survey, even though these entities had the largest freedom of movement during the state of emergency.

How did you deliver your printed equipment to the destination?

<i>Organized volunteers</i>	56	50,91%
<i>I took them to the destination</i>	34	30.91%
<i>Police or Guardia Civil</i>	33	30.00%
<i>Non Organized Volunteers</i>	29	26.36%
<i>Delivery</i>	10	9.09%
<i>Other</i>	8	7.27%
TOTAL	110	100%

Table 7. How did you deliver your printed equipment.

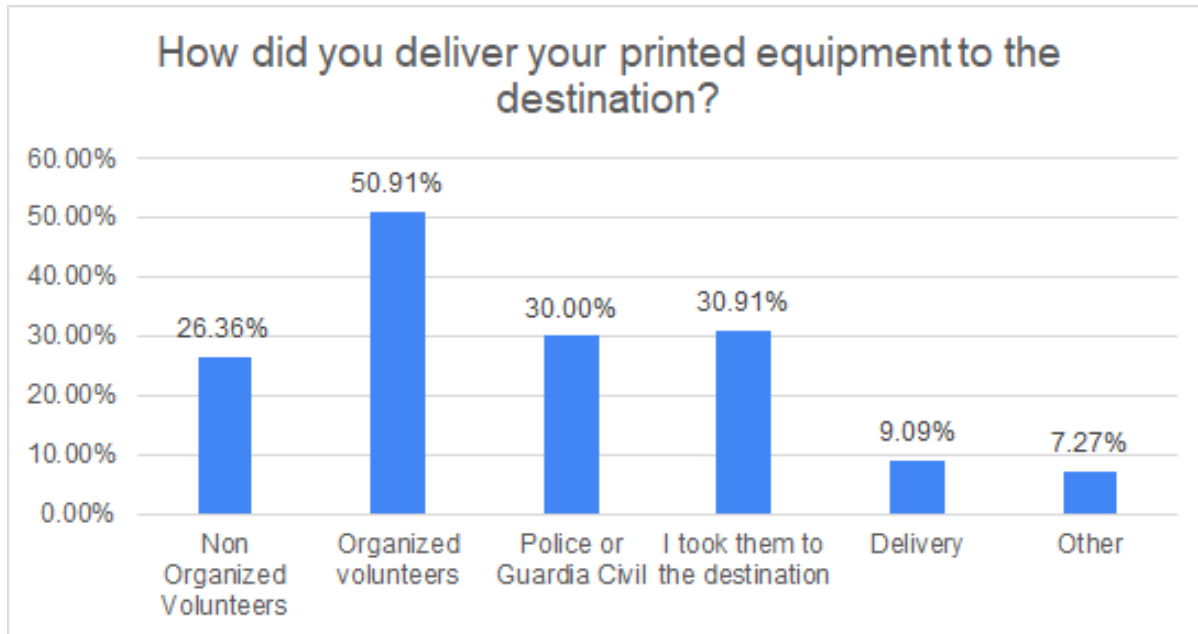


Fig. 8. How did you deliver your printed equipment.

How did the Coronamakers community organize to produce and deliver the printed equipment?

For this question we allowed the surveyed to choose all used options in the questionnaire. Later we asked them to highlight the most used option. In all cases Telegram was the most selected option, with a higher score than other tools like Whatsapp. 94% of makers work at least once through Telegram, while only 39% did the same using Whatsapp.

If we only consider the most frequent tool used, Telegram receives a 88% score and Whatsapp descends even more to a 7% score. Other options like Twitter, Instagram or mailing lists show almost an inexistent usage.

What technological tools are you using to communicate and coordinate with other members of the makers community?

<i>Telegram</i>	94	94.00%
<i>Whatsapp</i>	39	39.00%
<i>Twitter</i>	12	12.00%
<i>Instagram</i>	7	7.00%
<i>Listas de correo</i>	5	5.00%
<i>Otro</i>	9	9.00%
TOTAL (N)	100	100%

Table 8. What technological tools are you using to communicate?

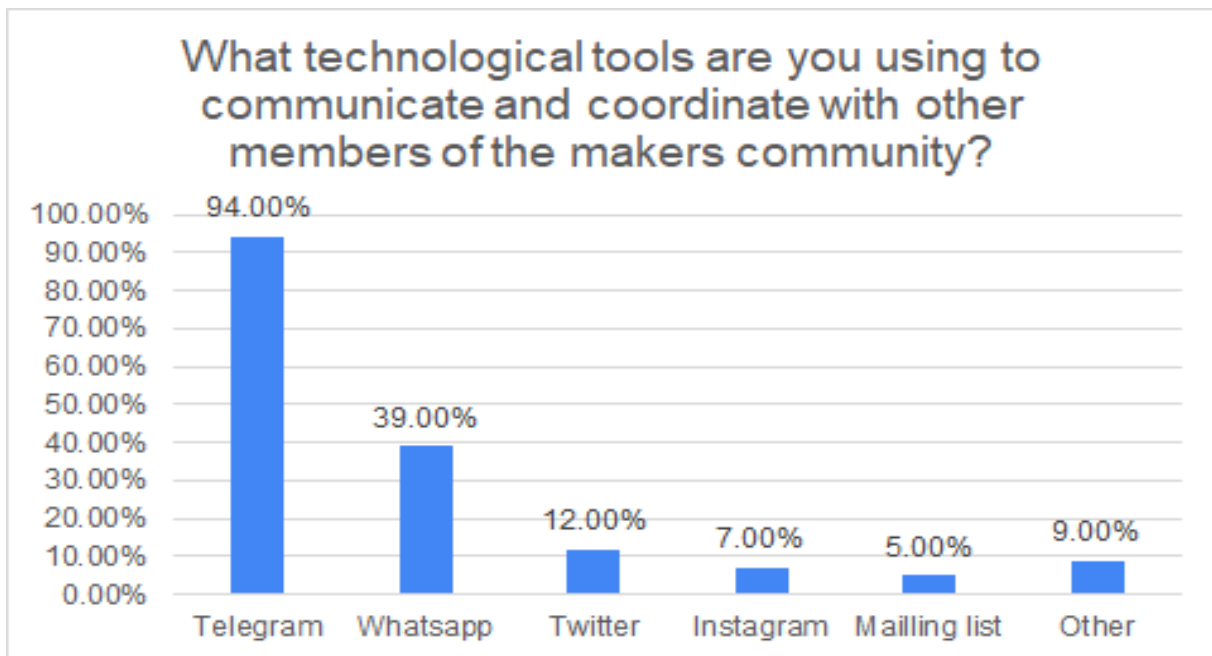


Fig. 9. What technological tools are you using to communicate?

Which technological tool was the one you used the most to communicate and coordinate with other makers in the community? Choose only one option.

<i>Telegram</i>	88	88.00%
<i>Whatsapp</i>	7	7.00%
<i>Twitter</i>	1	1.00%
<i>Instagram</i>	0	0.00%
<i>Listas de correo</i>	1	1.00%
<i>Otro</i>	3	3.00%
TOTAL (N)	100	100.00%

Table 9. Which technological tool was the one you used the most?

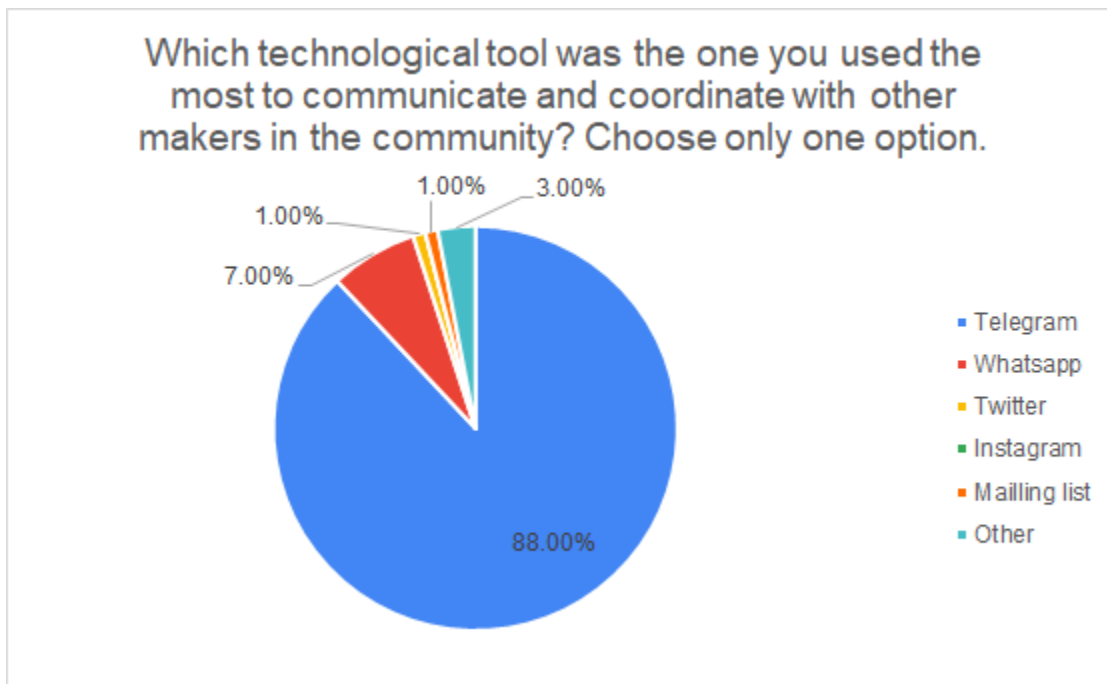


Fig. 10. Which technological tool was the one you used the most?

Conclusions

Before discussing the findings, it is important to highlight a critical reflection about the results. It is important to look at the gap between men and women responses. We do not have data about this gap into the total Coronamakers population. It is not possible to us to know if this gap in our data a reflection of an actual gap inside the target population or by contrast it is a gap caused by reasons with regard with gender that has affected to agree to participate in the survey or refuse it. This is the main limitation that we can identify in our research and a future study about this gap is highly recommended.

Discussing the findings from our overall study, we can first conclude that the existence of local and regional makers communities prior to the pandemic, combined with the network of preexisting volunteers, allowed the quick organization of the Coronamakers community in an adverse and unprecedented reality to which we were pulled in during the pandemic. This conclusion is based on that most of the participants in the campaign for 3D printing of medical equipment during the coronavirus crisis belong to a certain 3D printer community (86.36%) and only 13.65% considered their participation in the campaign as a personal and individual initiative.

Thus, as main conclusion and recommendation, we believe that there is a need to encourage the work of communities from the social organizations, as well as institutions and public administrations, which will also allow the growth of new networks of cooperation between the mentioned entities in expected or unexpected pandemic situations. This conclusion is supported by the fact that organized volunteer groups was the most used option to get the products to their destination in this case (59.91%), even more than institutional groups like police and *guardia civil*, selected only in 30% of the cases as an option to deliver printed equipment. Specifically, 89.29% referred to volunteer like the Red Cross and other organized

entities created prior to the pandemic makers groups rather than the Coronamakers group in their responses. Only by defining and implementing this model of cooperation, in moments of crisis it will be possible to create a quick and effective response to unexpected situations.

These recommendations should be stronger in those area which have special difficulties to access to public health resources, including materials as PPE, or deficiencies in logistic networks for distributing them. For example, our data suggest that 3D print could be an important tool for fighting the spread of a virus in pandemic situations also in developing countries. Some of the problems experienced by the special situation of the COVID19 pandemic in Spain may be common in other political and social context without a complete logistic connection by roads and a lack of economic and material resources. It is to be expected that new problems may arise in those contexts, as difficulties to launch a 3D print community in territories with internet or electricity problems. For example, our data show that making communication easier for the different 3D printer community with internet solutions facilitate to overcome the barriers that can appear during current and future pandemic situations. For example, 94% of makers work at least once through Telegram to coordinate their work with the community. Besides, our data show that the majority of the members of Coronamakers community printed their 3D medical equipment at home (87.39%). Maybe, other options like FabLabs or social centers like schools or universities will be more suitable in other contexts. Due to these and other issues, a focused research about how to apply the knowledge acquired by Coronamakers community in Spain in those contexts is a strong recommendation derived from our study.

Finally, it will be very welcomed similar studies about similar initiatives carried in Spain or in other countries with similar or different characteristics.

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