How makers responded to the PPE shortage during the COVID-19 pandemic: an analysis focused on the Hauts-de-France region

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ABSTRACT

The COVID-19 pandemic led to the confinement of populations in France on the one hand and to shortages of equipment on the other hand (in particular Personal Protective Equipment). The makers therefore mobilized worldwide to produce this medical equipment. In the Hauts-de-France region, a group of makers organized to produce face shields for hospitals, public health and social care institutions and also for retailers. Our analysis of the collaborative messaging room used to coordinate the production of face shields was completed by the interview of active makers. It was based on an original tool-based integrated and hybrid (quantitative/qualitative) methodology. That work enabled us to update the profile of the participants, the intensity of their contribution, the nature of the innovation implemented, the coordination mechanisms, the associated difficulties and the role of technologies in the makers' response.

CCS CONCEPTS

• **Collaborative and social computing systems and tools**; • **Open source model**;

KEYWORDS

COVID-19, makers, fablabs, collaborative innovation, collaborative platform

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1 INTRODUCTION

The month of March 2020 was marked for many European countries (Italy, France, Belgium...) by the exponential spread of COVID-19. Due to the lack of anticipation by governments and tensions over supplies of medical equipment, confinement measures were applied, particularly in France and Belgium [8]. The mobilization of the makers was particularly noticeable in their efforts to provide masks and face shields for healthcare workers, but also in their participation in the emergence of more complex open source projects such as respirators.

In the French region of Hauts-de-France, a group of makers mobilized and coordinated through a series of Riot rooms [3], a collaborative messaging client compatible with the open source Matrix protocol, which is a more open alternative to Discord or Slack. The "*3D printed face shields*"[1] room was the subject of an analysis aimed at understanding the type of innovation, the nature of the productions and the coordination mechanisms implemented by these makers.

This research is organized in four sections. In the first section, we present the makers movement and its possible contribution in a crisis situation. In the second section, we present the methodology used. We develop the software used, especially those available in the form of online services, and their integration into a hybrid quantitative and qualitative methodology. In a third section, we present the results. In a fourth section, and before concluding, we discuss the research methodology and the results obtained.

2 MAKERS AND COVID-19

Popularized by [1], the makers movement covers in practice the massive democratization of production tools through, on the one hand, digital manufacturing tools (including 3D printers and laser cutters) and, on the other hand, the development of open source software and hardware, including several popular 3D printing models (e.g. Prusa, Makerbot and Ultimaker).

The maker movement has been accompanied by the creation of third places: techshops, hackerspaces, fablabs... Dedicated to digital manufacturing, the fablabs are supposed to follow specifications defined by the MIT Center of Bits and Atoms (CBA) including the respect of minimal equipment [21]. The term "fablabs" has subsequently been used to designate third places dedicated to digital manufacturing and open to collaborative practices but not necessarily meeting MIT specifications. In addition, fablabs depend on government entities, institutions (public or private) or universities [4]. Therefore the initial objective of sharing can be complemented by more commercial objectives. Fablabs can be seen as "*global*" places because they are both "*embedded in local economic networks*" and subject to global pipelines as soon as, for example, they adhere to the MIT's fablab charter [20].

Fablabs are de facto included in broader structures. [18] has proposed a framework for analyzing the interactions between formal

[1] The expressions and the verbatim in French were translated by the authors

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organizations and informal actors through the concept of "*middleground*". The latter is a meta-platform that links the activities of an underground with those of an upstream. This "*middleground*" is characterized by 4 elements: "places" (physical), "spaces" (cognitive), "events" and "projects". In this model, fablabs can be seen as an element of the "*middleground*" producing digital commons respecting the principles of open source governance [7]. In their analysis of Belgian and French makers COVID-19 projects, [24] note the existence of a structure on three levels articulating large organizations ("*upperground*"), fablabs ("*middleground*") and makers ("*underground*") with a link to global platforms allowing the centralization of knowledge produced according to the principles of open source innovation [17].

The crisis related to the COVID-19 pandemic accentuated the lack of resilience of European states where the risks were underestimated and the response (at the beginning of the pandemic) proved to be ineffective (lack of masks, overloading of hospitals, lack of tests...) imposing a rapid confinement in order to try to drastically reduce the circulation of the virus [8]. In terms of resilience potential, [19] recalls the debate between centralization and decentralization, standardization and local autonomy, control and capacity building, efficiency and responsiveness. The key would thus lie in a planning effort coupled with the creation of processes that stimulate latent resilience by encouraging positive adaptive behavior. In this scheme, belonging to communities, to extended relational networks, is considered in the literature as a resilience factor. Makers form such networks outside of their affiliating organizations. In the past, makers have been able to demonstrate their usefulness in crisis situations. Examples include the manufacture of portable radioactivity sensors (Safecast devices) following the Fukushima disaster in 2011 and open data publication activities for monitoring radioactivity [13]. This was driven by a movement made up of makers, entrepreneurs, companies and above all citizens, it was not limited to the makers alone.

The COVID-19 pandemic highlighted the role of citizens in the production of artefacts (knowledge, accessories, equipment...) useful to help cope with the crisis. It is the case for open data usage [6] and makers productions [5]. The mobilization of the makers within collectives (e.g. "Makers contre le COVID") was the subject of considerable media coverage[2]. As [24] showed, attention on their productions was focused on personal protective equipment (in particular face shields), accessories (e.g. valves and syringe pumps) and respirators (e.g. the Breath4Life project in Belgium and the MakAir project in France). Fablabs often played a central role in these productions, playing a coordinating role and mobilizing their tools to meet the most immediate needs.

Considering this huge investment of makers in the COVID-19 crisis, we analyze here how do they coordinate (especially in confinement conditions), how do they innovate, what were their real outputs and how were they integrated to a more global institutional response?

[2]Cf. https://www.lemonde.fr/pixels/article/2020/04/23/les-visieres-imprimees-en-3d-une-reponse-des-makers-a-la-crise-sanitaire_6037538_4408996.html for an example.

3 METHODOLOGY AND TOOLS

Our methodology is based on a qualitative approach [15], focusing on the textual content of an online discussion room and the content of semi-structured interviews, supported by automated analysis tools.

3.1 Qualitative analysis

The core of our methodological approach is based on qualitative analysis. Two types of material could be analyzed qualitatively: on the one hand, the exchanges in the "*3D printed face shields*" chat room of the Riot "Hauts-de-France", and, on the other hand, interviews with various protagonists who participated in the design of 3D face shields. The qualitative analysis follows the precepts described by [15]. The latter proposes an implementation of the anchored theorization method. Allowing for a better understanding of the actors, it assumes three types of coding: open, axial and selective. Rejecting both theoretical ignorance and inherited theories, [15] invites a theoretical sensitivity that offers a compromise between an overly strict framing of the research and an insufficiently marked out exploration of the field. The reproducibility that is important in scientific research here concerns the process rather than the outcome. We applied the method, on the one hand, to the textual content of a Riot chat room, and on the other hand, to the content of the interviews.

The observation field of our analysis is the Riot "*3D printed face shields*" messaging room (see 1). This technological tool was used in the Hauts-de-France (France) to coordinate the activity of makers with digital manufacturing machines, in particular 3D printers, capable of producing face shields useful as personal protective equipment.

The second analysis was applied on semi-structured interviews that were conducted with the help of an interview guide and then transcribed. The coding of the interviews was carried out in an iterative way and was accompanied by the progressive feeding of a logbook.

3.2 Technological aspects

This research mobilized two specific tools: on the one hand, Riot (renamed Element) and on the other hand the Cognitive Services of Microsoft Azure.

Riot is a collaborative messaging client based on the open source Matrix protocol. This technology notably enables the creation of chat rooms and can therefore be used within the framework of collaborative projects. It thus provides an alternative to Slack and Discord. These tools were intensively used by the makers during the first confinement (COVID-19) to synchronize their activities in a context of drastically reduced freedom of movement.

Microsoft Azure is a public cloud computing service of IaaS and PaaS types depending on the functionalities used. We are interested here in Cognitive Services, i.e. "*a complete family of artificial intelligence services and cognitive APIs to help you create intelligent applications*", and more specifically in the "Microsoft Speech" and "Language" sections. The first covers speech processing and, in particular, voice recognition, which allows a recording to be transcribed. The second covers the analysis of unstructured text, including in particular the analysis of sentiments and the extraction

Table 1: Characteristics of the observation fields

Criteria	Value
Number of participants:	25
Number of items:	1749
Start of activity:	March 28, 2020
End of activity:	May 14, 2020
Duration of activity:	47 days

Table 2: Information related to interviewees

Participants	Function	Duration
Participant n°5	Engineer (school of engineering)	00:41:52
Participant n°1	Engineer (medical research)	02:41:07
Participant n°3	Engineer (school of engineering)	01:54:04
Participant n°10	Entrepreneur (3D printing)	01:08:44
Participant n°2	Engineer (school of engineering)	01:48:17

of named entities. These services benefit from complete documentation, in French and English, accompanied by numerous examples of source codes written in different programming languages (including Python). In this way, the appropriation of these services is greatly facilitated. Pricing is on a per-request basis, but free of charge option is provided for a certain number of monthly transactions, which facilitates testing and encourages use on smaller volumes of data. Overall, the tariff remains below one euro per thousand transactions. To activate the service, users need to associate a payment card with their Microsoft Azure account and then create the resource corresponding to the desired service (e.g. "Text Analysis" and "Speech") in the Microsoft Azure administration interface. Azure then communicates two access keys and an endpoint to be reused in each of its scripts.

Our analysis therefore focuses on a chat room operated on the Riot platform compatible with the open source Matrix protocol.

Extraction of the content of a Matrix-compatible chat room is possible with the "Matrix-dl"[3] software (available on Github). The latter allows the content of a chat room to be extracted and saved in a weakly structured text file. A pre-processing step (Python script) is therefore necessary in order to segment the day of publication of a message, the time, the sender, the possible recipients and the content of the message. This information can be saved in a "csv" file, not very suitable for very large data sources, but easy to process in Python ("csv" library) and in spreadsheet software such as LibreOffice.org Calc or Microsoft Excel. As the discussion channels studied did not produce more than a few hundred or thousands of messages, this technical solution was retained.

The "csv" file can then be processed in three different ways. The first concerns the measurement of the evolution of the room's activity, via the number of messages posted per day, and its graphic representation. The second process involves extracting the pseudonym of the contributors and calculating the number of messages posted to the room. The identification of the most active contributors is useful information for the organization of any interview (if fieldwork is planned). The third treatment consists of extracting the relationships between the contributors, through the exchange of messages. These data, extracted in Python, can be exported in "dot" format and then visualized in the Gephi software. The latter can then be used to calculate graph analysis metrics such as Pagerank or betweenness centrality.

The information in the "csv" file can then be enriched by Cognitive Services. Two services are used here: the extraction of named entities and the sentiment analysis. While the first provides a result of poor quality (perhaps due to the approximate syntax of chat rooms), the second makes it possible to identify messages according to their polarity. A distinction must be made here between non-conflicting messages, but carrying positive or negative information, and conflicting messages. The researcher will collect these second messages when conflicts arouse his interest (see [24], for an example). The calculated data are recorded in a second "csv" file.

The second "csv" file is then integrated with the first one in a LibreOffice.org Calc workbook, the concatenation of the date and time of each message providing a key to gather for each message the information useful for the analysis. Conflicting exchanges are easily identified in the spreadsheet by the succession of negative messages in a block of contiguous messages. An average positivity score can also be calculated for each member of the message room.

This analysis using the exchange platform facilitates the identification of important protagonists, due to their prolixity, their involvement in conflicts or their commitment in the general interest projects. They can then be selected for a semi-directive interview in order to gain a more in-depth understanding of the phenomenon being studied. Qualitative approaches (see for example [15]) recommend recording interviews. The speech to text service of Cognitive Services allows the automation of the transcription (count one hour of calculation for two hours of interview). Correcting the automatic transcription requires one hour of work for every 20 minutes of recording and therefore saves about 50% of the time of a manual

[3]Cf. https://gitlab.gnome.org/thiblahute/matrix-dl/

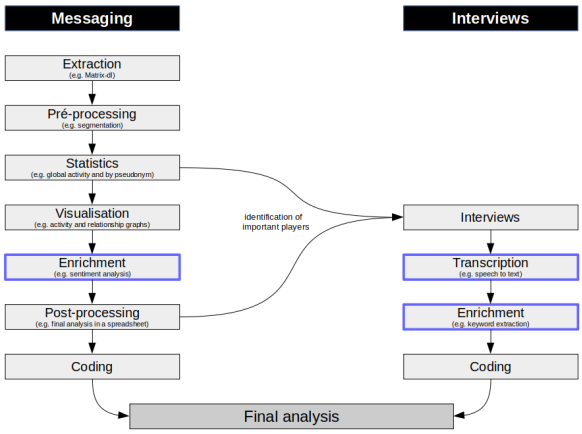

Figure 1: Global methodology and tools

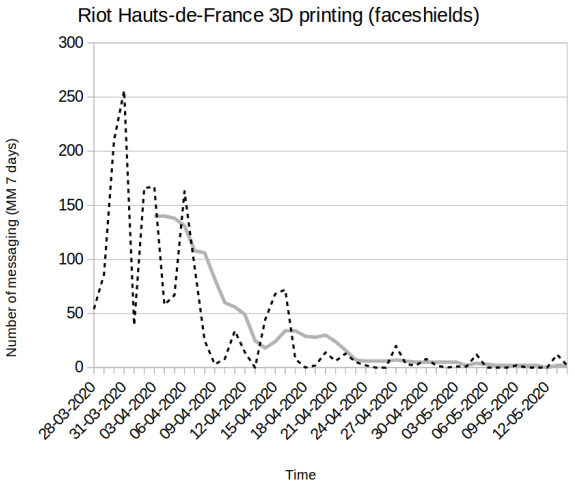

Figure 2: Evolution of members' activity

transcription. The document can then be coded [15] after possible automatic extraction of keywords (e.g. named entities). The 2 contains information related to interviewees.

In summary, this analysis therefore combines message extraction with the "Matrix-dl"[4] software (available on Github), their segmentation (Python script), a calculation of activity statistics, sentiment analysis[5] of messages (via Microsoft Azure Cognitive Services), a graph analysis (with the Gephi software) supplemented by a calculation of metrics [12] as well as coding of the 1,749 entries in the collaborative messaging room [15] and lastly the interview with five participants in the discussion room. The segmented data are manipulated and analyzed with LibreOffice.org Calc, which remains valid for discussion channels with no more than a few thousand entries.

3.3 Integrated analysis

The case study relating to the automated analysis of a collaborative messaging room enables us to propose a tool-based analysis methodology (see Figure 1). The rectangles framed in blue highlight the steps that can be automated using Cognitive Services. These, because of their "black box" side, will undoubtedly frustrate researchers who are experienced in text analysis techniques. For the others, these will simplify the prototyping of data processing chains (even if it means replacing them with mastered bricks at a later stage; cf. [23] for some examples of open source reusable components) and will encourage adoption by a wider range of researchers thanks to the lower technical skills required. Indeed, it should be remembered that adoption depends on two dimensions: perceived utility and perceived usability [2].

Collaborative innovation is today widely visible through online exchange spaces (discussion forums, social networks such as Twitter, messaging platforms such as Slack, Discord or Riot...). The analysis of threads can be done manually or automatically. Manually, it can be equipped with qualitative analysis tools such as NVivo and Cassandre. However, these are not dedicated to the analysis of messaging. Given that it's automatic, it relies on collection, backup and analysis solutions, whose complex implementation requires the availability of solid technical skills (see [14] for an example). Some tools are emerging to facilitate the creation of specific processing chains (e.g. R software and its multiple extensions [16]). The tool-based methodology presented here proposes an intermediate path. While programming skills are still required, these remain limited and can be based on abundant documentation with many commented examples of source codes. The result also allows for a control of the processing chain.

[4]Cf. https://gitlab.gnome.org/thiblahute/matrix-dl/

[5]Sentiment analysis makes it easier to identify messages of potential conflict and to identify members who are more involved in such conflicts

4 RESULTS FROM RIOT ANALYSIS

The results relate to three distinct aspects: firstly, the activity of the members; secondly, the links between these members (traceable from exchanges); and, thirdly, the nature of the exchanges making it possible in particular to understand, on the one hand, the contributions of this community to the response in times of crisis and, on the other hand, the innovation process implemented.

4.1 Members activity

Analysis of the activity shows that five members produced almost two thirds of the messages posted in this chat room during the period of activity. It thus reflects an application of the law of power of participation [1]. The long tail of less prolific participants is not without interest, however, and includes quality contributions. For example, while the participant n°1, who was responsible for 21.68 % of the messages, played a central role in the design of the face shields, the participant n°8, who was responsible for "only" 3.38 % of the messages and only made more occasional contributions, provided useful expertise in the production and delivery of the face shields (see 3).

Activity was at its peak when the room was first created, before rapidly decreasing (see Figure 2; moving average as a gray solid

Table 3: Members' activity

Participants	Number of messages	Part of messages	Cumulated (%)
Participant n°1	379	21.68 %	21.68 %
Participant n°2	330	18.88 %	40.56 %
Participant n°3	140	8.01 %	48.57 %
Participant n°4	130	7.44 %	56.01 %
Participant n°5	113	6.46 %	62.47 %
Others	657	37.53 %	100 %

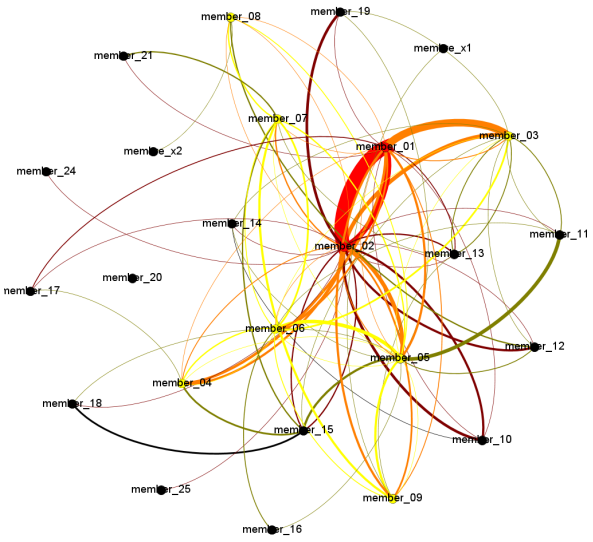

Figure 3: Relationships between members (anonymized)

line). In practice, the design activity shifts to the production and delivery of the face shields (coordinated in another room) once the design has stabilized.

4.2 Links between members

The centrality of a minority of members is reflected in the graphical representation (see Figure 3). The latter makes it possible to visualize a core of the few most active members. The color codes reflect the prolixity of the member (red: more than 250 messages; yellow: less than 250 messages but more than 50; black: others). The thickness of the links shows the importance of the exchanges between members. The participants have more or less specialized contributions. Participant n°2 thus focuses on facilitation, motivation and the dissemination of information. His role as facilitator (and guarantor of the cohesion of the group) is reflected in the highest score for betweenness centrality.

4.3 Relationships, contributions and conflicts

Sentiment analysis allowed us to identify a brief conflict section (about 10 messages) on a classic theme in open source / open hardware / makers environments: respect for licenses and cultural norms specific to the community [10]. In this case: the respect of the NC (non-commercial) clause of the CC-BY-NC license and the profits made (or not) by companies providing face shields created on the basis of validated designs and published under a Creative Commons license. This lively exchange takes as its starting point a trivial question from a service provider (participant n°10) as to the license applicable to a face shield model that he is likely to produce on his machines and the reactions of makers (participants n°1 & n°2) to the margins made by certain service providers: "*I think it's a shame to feel like persona non grata for that*"[6]. This exchange, largely marked by misunderstanding, ends with a reminder of the license applied: "*No, everyone doesn't do what they want. If there are licenses, it's not for nothing. Selling Prusa face shields 10€ is illegal, it's a CC-BY-NC, so it's completely, completely illegal, and we'll have to remember that at the end!*" Moreover, it resulted in a complete disengagement of the targeted member (after a last message that was perfectly neutral).

4.4 Innovation process

The coding of the chat room made it possible to understand the innovation process implemented by this community.

The first stage of this process, which is iterative, is a back and forth process between design and (small-scale) production. The iterations on face shield design are based on feedback from users, manufacturers and health professionals, on comfort of use (head contact, nose size, use of glasses, etc.), sterilization (hygienists; e.g. "*the surface finish is too rough and the hygienist requires something smoother to ensure sterilization by dipping in diluted bleach*") and production (speed, surface finish, strength, post-production... and printing configuration on different machine models). In addition, they also allow for a variety of face shields models to be offered depending on the equipment available, the raw materials and the target audience (e.g. retailers and carers). Designs can be locally innovative and/or based on global designs (e.g. "Dagoma", "Verkstan" and "Prusa" face shields). This step poses a recurring problem of centralizing documentation and designs, a task made complicated by variants and versions. For the "3D printed face shields" Riot room, this was achieved with the OnShape collaborative platform dedicated to computer-aided design, in addition to Etherpad and the room itself (for PDFs). Designs are subject to validation based on feedback from users and reference organizations[7]. Once validated,

[6] The expressions and the verbatims in French have been translated by the authors.
[7] Cf. https://www.onera.fr/sites/default/files/actualites/breves/CASQUE-COVID-19-CNRS-DR14.3-3.pdf for an example cited in the room

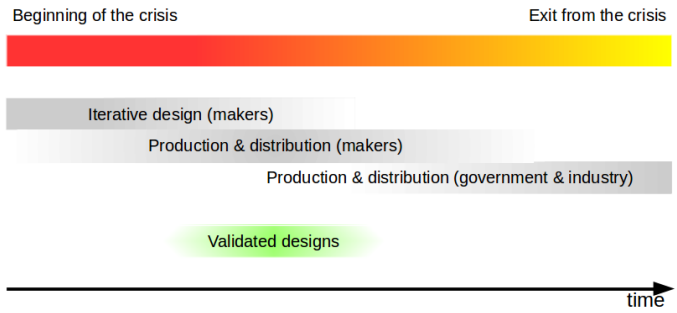

Figure 4: Temporal representation of the action of the makers

they must then be disseminated within the group and possibly to other platforms working in parallel.

The second stage concerns the move to scale. It involves setting up separate logistics for voluntary and institutional makers (e.g. employees of fablabs and industrial companies). The latter are better able to guarantee a certain level of quality and to coordinate with hospitals. In addition, they have equipment that individual makers do not have (e.g. laser cutters and industrial cutters). This logistics includes in particular the supply of raw materials (in a context of frequent stock shortages), the identification of priority needs (e.g. hospitals), with the implementation (on Google Sheets) of a needs and delivery inventory sheet, and taking into account restrictions on movement (confinement) when delivering to beneficiaries. It is at the level of supplies and withdrawals that collaboration between individual and institutional makers (fablabs, tech shops, industry employees, etc.) comes into play, the latter having travel permits provided by their employers.

The public exhibition is also reflected in the construction of the identity, notably through the name and logo associated with the collective.

This process took place over a month and a half before the crisis situation was resolved, the standards[8] (health, economic, fiscal, etc.) were recalled and the state and industry took over (see Figure 3). The makers thus contribute to the design and selection of one or more dominant designs [22] which can then be mass-produced, on standardized machines, with a low cost price and constant quality, by industry.

5 RESULTS FROM INTERVIEWS

Conducting interviews with people identified, on the one hand, during the content analysis of the "*3D printed face shields*" chat room, and on the other hand, following the graph analysis applied to the exchanges on this same chat room, made it possible to refine the understanding of the coordination of the makers on three levels: the start of the cooperation, the organization of the makers' response and the motivation of the actors.

5.1 Start of cooperation

The creation of the "*Hauts-de-France*" chat rooms came about as a result of the formation of a task force (Polytech, Centrale, CHU Lille) around the problem of the shortage of medical equipment's spare parts, particularly for respirators. Exchanges started with e-mails, then continued on a "*Riot*" chat room (to compensate for the inefficiency of e-mail and to widen the audience), before spontaneously turning to the production of face shields. This evolution can be explained by two factors. On the one hand, the problem of out-of-supply accessories was solved by implementing decontamination procedures and reducing the dependence on disposable products (e.g. RFID chip part that cannot be used after a certain number of uses). On the other hand, the need for personal protective equipment quickly emerged, which motivated the work of the "*3D printed face shields*" chat room. The real objective of the collaboration thus gradually moved away from the initial objective of networking.

> "I think that the Riot was only possible because <participant n°2> was there. That is to say that he very quickly put himself outside the technical discussions, whereas he could have been involved. But he saw very quickly that someone was needed to orchestrate all this. (...) But he took on the role of trying to manage the tensions that might arise or the difficulties, of taking initiatives, of moderating all that, in other words, of creating the chat rooms very quickly. (. . .) In fact, he was there, he was the moderator of the thing, that is to say, he would identify when a discussion was going a bit out of hand. He would advise people to go to such and such a chat room. Or when there was a discussion that was starting to grow, to say wait, instead of polluting this thread, I've created a dedicated chat room for that." (interview: participant n°3)

Eventually, an engineer employed by Centrale took on the role of coordinating the Riot exchange platform. This led him to specialize the rooms, distinguishing three purposes: the production of face shields, the production of accessories and the production of respirators. In the "*3D printed face shields*" room, the collaboration was focused on: face shield design, production optimization and logistics. This organization made it possible to channel energies and avoid the disruption of priority projects (e.g. face shields) by

[8] Cf. https://fabricommuns.org/2020/05/12/realisation-de-visieres-de-protection-nouvelles-normes-et-loi-impactant-les-makers/ for an example cited in the room

peripheral projects whose feasibility and usefulness were more questionable (e.g. respirators), without depriving them of a dedicated collaboration space.

5.2 Organization of the makers' response

The organization can be divided in three steps: the conception of the face shields, their production and then their delivery.

5.2.1 Conception of face shields. The face shield (also called "protective face shield") consists of a headband to which is attached a transparent plastic shield that covers the face. A design of the headband and its fixing to the plastic must be modeled, tested and validated to be optimally printed and assembled. In practice, several designs emerged, which we will refer to as the "Dagoma" face shield, the "CHU" face shield and the "Plastisem" face shield for ease of reference. The general inspiration was given by the face shield proposed by Prusa Research[9] (no feedback to Prusa Research was given). After it was found that this face shield took a long time to print, an adapted model was designed and validated by the nursing staff of the hospital. We will call the face shield "CHU" (also known as "Laurent" face shield in the dedicated lounge, after the designer's first name). For its part, Dagoma chose to produce in maximum quantity (i.e. 10,000 Dagoma face shields in PLA per day at the height of the shortage). The design was therefore conceived so that the face shield's headband structure could be stacked on the 3D printing machines and produced in large quantities. We will call it a "Dagoma" face shield. A third model was then created for plastic injection. The design was based on the "CHU" face shield, which was then modified by Dagoma (3D printer manufacturer) and Plastisem (plastics manufacturer), allowing a mold to be designed quickly and then put into production. We will call this design the "Plastisem" design. 3D printing has since been used profitably not only for production but also for rapid prototyping of molds (allowing very short design times).

> "In fact, there is either an objective to increase production rates, or an objective to satisfy comfort, or an objective to satisfy the technical validation of medical personnel, or an objective to satisfy the ego of one or all of these people. (...) And so in fact there are no good or bad solutions. (...) [Company]'s choice was to say: we are going to give the biggest possible boost in terms of quantities. (...) And so, in fact, we came up with a very thin design because I think that on the last versions, our face shield was 11 grams, so 11 grams to print is necessarily less than 20 grams." (interview: participant n°10)

Other variations, or even completely different designs, were produced. These included designs adapted to specific tooling (e.g. laser cutter) or designs created by makers with expertise in engineering, 3D printing and medical devices (e.g. cartridge mask[10]. These designs could be published on Thingiverse.

> "It's because I was the one who imposed OnShape. So it was hard for me because it wasn't open source. I had a lot of trouble accepting to impose a non-open source thing, but as it was the only distributed CAD tool which meant that you could work in a group without having to install anything. It was good actually. So you see what made it work in the end was the choice of tools and the imposition of a method." (interview: participant n°2)

The "CHU" design was carried out through visible exchanges on the "*3D printed face shields*" room of the Riot "*Hauts-de-France*", completed by frequent evening video exchanges at the initiative of a core group of 5 or 6 people strongly involved in the initiative. The collaborative work was based on OnShape, an online CAD/CAM tool, which is free for non-commercial use, and therefore not open source, unlike Freecad, but which provides a homogeneous collaborative tool. From this tool, an STL file could be extracted for dispatch via other channels (e.g. email). In practice, other designs were developed according to the needs expressed by the audiences consulted (e.g. intensive care staff). The Riot chat rooms were complemented by an Etherpad widget whose content was lost when Riot was renamed Element.

5.2.2 Production and delivery of face shields. Once the designs had been validated and communicated, production could begin. Given the heterogeneity of the 3D printers used, a collaborative effort was required to configure the machines. This was facilitated by the open nature of the open source machines and their use of the gcode language.

> "We had 2-3 users like that who contacted us saying I use such and such a machine but I've never used such and such a material, how could I do it? So I didn't have the machine, but as it's open source, I got a profile. And on this profile I did the slicing and sent them the code that they could install on the machine to make it work." (interview: participant n°3)

Once the face shields were produced, local logistics had to be put in place. In practice, production was centralized at the central pharmacy of the Lille hospital, with a delivery note indicating the model and material used, which then allowed distribution within the hospital (validated model, material compatible with disinfection products) or redirection to other recipients according to the needs expressed. Deliveries were made by a Polytech employee with a travel certificate.

> "I was talking to a reanimator who had worked on the M.U.R. (respirator) project (...) and he was the person who had explained all the constraints to them and so I worked again a little bit with these people,(...) so that I could try to understand the real constraints. And when we understood the real constraints of reanimation, we realized that, in fact, it was useless. There were many things, for example, flow controls which were not ensured even though it was one of their main controls. And the pressure control was really complicated for them to use. So we realized that there were technological challenges for which we should have had a real structured team to do it. This is what MakAir did, for example." (interview: participant n°2)

[9]Cf. https://www.prusa3d.com/covid19/
[10]Cf. https://www.thingiverse.com/thing:4385769)

In addition to face shields, makers have turned to respirators. These are complex medical equipment requiring a minimum of engineering skills and input from specialists in reanimation. The energies on respirator projects, deemed of little use in practice, were channeled into dedicated rooms on the Riot, so as not to disrupt rooms deemed to be of priority (e.g. face shields).

The production of face shields was abruptly stopped (except for some EPHAD needs) after a reminder of the standards in April 2020 by the ANSM. Compliance with these standards would have required certification, which would have been financially costly, and which was not undertaken by any actor involved in 3D printing. This event has had a major effect on the motivation of the makers and clarified their relations as "*underground*" with the "*upperground*" (authorities).

5.2.3 Motivation of the actors. The facilitation of makers communities' platforms necessarily raises questions about the value and the usefulness of the contributions as well as the motivation of the contributors (e.g. do they expect recognition?). Riot's activity was essentially oriented towards the production of face shields, which met a real need in the field. However, some goodwill was directed towards respirators, which posed challenging technical problems, but for which the skills were not available. These contributors were therefore brought together in specific discussion rooms.

> "That is to say that everyone was doing it with bits of string. I mean, nurses ended up with plastic bags instead of scrubs because everything was broken and the day it started again, instead of saying thank you for having provided the interim, we were told to be careful, you're going to have to stop because we could turn against you." (interview: participant n°3)

As for recognition, it came up against the authorities' reaction, which was considered brutal. The end of the crisis left a sometimes bitter taste of non-recognition, or even abuse of the goodwill present at the height of the crisis.

> "It wasn't always a good experience for some people. Because when you go to the central pharmacy to drop off face shields, it's much less rewarding than going directly to the hospital to take a photo with the nurses, which is great for your Facebook." (interview: participant n°1)

As for the small producer-makers, their satisfaction lies sometimes in the recognition of a personal design, which can lead to ego problems, and sometimes in the recognition of a delivered production (e.g. posting a photo on Facebook), which can be countered by optimizing the logistics (centralization). In the case of members employed by a health organization, recognition may have come indirectly from the institution itself (e.g. bonus).

5.2.4 Conflicts between actors. Several fracture lines appeared on the Riot, firstly between the makers in the strict sense of the word and the members from the business world, secondly between the industrialists and the other members (on questions of organization), and thirdly between the "knowers" and the tinkerers.

> "there was a lot of misunderstanding. That's why we made a blog post, so you'll find on our site if you look a bit why we sell our face shields and why it's at cost price. There was a lot of misunderstanding, of "ah bah they make money on the back of the disease"." (interview: participant n°10)

In the first case, the conflict centered on questions of money, in particular the sale of face shields at cost price by a 3D printing company, where the makers gave their production, but where, on the other hand, speculation was noted among certain sellers. The animosity sometimes developed against 3D printing companies led the company to publish a press release which was then taken up whenever the controversy flared up in a discussion forum.

In the second case, the conflict, though less visible in public chat rooms, was about organization and in particular planning issues, with the logic of the manufacturers clearly opposed to that of the 3D printing machine users.

> "For example, on the respirators, we didn't typically have the automation and electronics specialists. We tried to approach them and get them to come in and we didn't get anyone. (...) I think that's also why it didn't follow up too well, whereas in fact we could have found someone who had this knowledge, we could have gone further. In fact, we very quickly came up against technical aspects" (interview: participant n°1) "the people who succeeded were really a team of engineers who made the MakAir, you see, you had people who really worked with engineering methods." (interview: participant n°1)

In the third case, conflicts arise between tinkerers acting by trial and error, sometimes making bad technical choices, with little support for prescriptions from experts. More complex objects such as respirators thus reveal the limitations of the "*make-to-learn principle*" [7] and the need of "*engineer mindset*" to build on solid technological foundation. The Riot messaging platform's exchanges proved to be less conflictual than Facebook-type social networks, which could be explained by the over-representation of a professional audience.

6 DISCUSSION

We discuss the profile of makers observed in the chat room and the future evolution of the innovation platform.

6.1 Types of makers

The expression "*makers' response*", which is widely used to describe the phenomenon under study, gives an impression of homogeneity in each contributing maker's role and profile, whereas the makers are diverse in nature and are divided into co-operative groups. We thus observe, on the one hand, isolated makers with limited resources (equipment, raw materials, etc.) and, on the other hand, sponsored makers, acting with the authorization (more or less formal) of their employer (fablabs, universities, small companies, big manufacturers, etc.) and with greater resources (more expensive equipment, stocks of raw materials, specific raw materials, etc.). What was highlighted by [25] is mainly the organization of institutional makers generally attached to a "*middleground*" in the sense of Simon (2009), in this case a fablab. However, they have collaborated with the makers in the classical sense of the term, on the one hand, through key people, present in several communities, sometimes

Table 4: Profiles of makers

Type	Affiliation	Goal
Pure maker	Hobbyist	Acknowledgment and/or fun (hobby)
Institutional maker	Public-sector	Suitability
Entrepreneurial maker	PME/PMI	Responsiveness
Industrial maker	GE	Efficiency

acting as "*knowledge brokers*", and on the other hand, through the urban logistics that have been put in place. The study of logistics allows us to distinguish a double flow with, on the one hand, centralized delivery rounds and, on the other, peer-to-peer delivery rounds. The latter were carried out by makers transferring parts from one place to another, depending on the traffic constraints imposed by the confinement, while the centralized tour also supplied certain makers with raw materials in exchange for production. We therefore have a coexistence between different more or less articulated networks federating institutional makers (Riot "*Hauts-de-France*") and makers in the strict sense ("Visières solidaires", "Makers against COVID"...), the latter generally coordinating themselves via social networks (e.g. Facebook).

The logistics of production and delivery of face shields therefore tends to be fragmented between, firstly, isolated makers, secondly, institutional makers and, thirdly, manufacturers. The exchanges within the collaborative messaging system also reflect the cultural differences between these different classes of players. On the one hand, the issue of licensing and production pricing emerges as an important point of attention from the contributors, while industry representatives tend, once the designs have been validated, to be focused on the optimization of the production and the delivery capacities (e.g. "*If you allow me, and without offending anyone, because you are all here to help, and that's great: You have to focus on production, you have to know what your production capacity is, as of today, and your daily delivery capacity.*"). In the end, this observation of the Riot chat rooms allowed us to distinguish 4 types of makers (cf. 4) with a dominance of institutional makers, contrary to what could be found on the Facebook groups more oriented towards makers in the strict sense, leading to sporadic smooth conflicts due to differences in motivations and goals.

6.2 Co-evolution of innovation platforms

Different makers' platforms are evolving here in parallel. Information can circulate between platforms following active members registered on several ones. In the same territory, platforms can operate in parallel, with little interaction, serving different target audiences. At the level of the Riot platform studied, success is based on different factors. On the one hand, there is the collaborative activity of iterative design, sometimes fed by designs proposed by high-visibility organizations. Ideally, it requires an efficient tool for centralizing designs, which has been lacking here (other makers in Belgium and France used Github or Gitlab, for example, to centralize the final designs ; [25]). On the other hand, the social usefulness of the productions presupposes a concerted work at the level of the local ecosystem, which implies frequent interactions with the

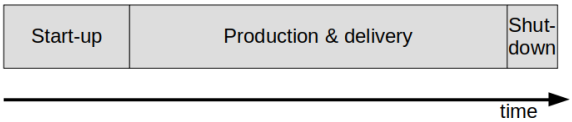

Figure 5: Resilience platform evolution

beneficiaries (needs, constraints, feedback...), the pooling of complementary individual expertise (search for common solutions) and the channeling of the contributors' energy (design, production...).

The platform dedicated to the production of face shields quickly withered away after the first confinement. After a start-up phase during which the individuals working together define the objectives and specify the organization, the platform enables production to be set up before an abrupt halt following a reminder of the PPE standards (cf. Figure 5). In the case of the face shields, although the "*upperground*" helped to stimulate the initiatives of the institutional makers, it did not collaborate formally with them. In practice, coordination with the CHU ("*upperground*") often took place informally and on the initiative of the field staff (informants, doctors, etc.). Contacts with officials generated reassuring speeches (e.g. at the Lille CHU), in contrast to feedback from the field, or very late (e.g. from the ARS). Therefore, if the initial impulse comes from the "*upperground*", the resilience allowed by this maker organization relies largely on the practices and machines available within the "*middleground*" as well as on the informal relationships existing between the "*upperground*" and the "*middleground*".

However, the spontaneous platform did not remain without descendants. Its social usefulness was indeed recognized locally, which made it possible to initiate the setting up of a 3D printing platform for health bringing together the same partners (CHU, Polytech and Centrale, Lille). The resilience platform is thus succeeded by an innovation platform, of which it was in a way the prototype. Moreover we thus believe we can distinguish between temporary production platforms (face shields) and sustainable innovation platforms (respirators). While the former offered a form of resilience in a crisis situation and benefited from a form of tolerance from the "*upperground*" before the latter took control of supplies, the latter led to more formal articulations justified by the complexity of the devices studied (e.g. respirators). This is for example the case of the MakAir respirator project which survived the first confinement and even led to deliveries to India in May 2021[11]. The future will show how much room is left for the "*underground*" in these new platforms

[11]Cf. https://www.ouest-france.fr/pays-de-la-loire/nantes-44000/entretien-une-centaine-de-makair-respirateurs-artificiels-made-in-nantes-produits-pour-l-inde-d3094990-b97a-11eb-a992-89f0a8dfc0f7

that are supposed to bring about active resilience [19], and whether their organization, their animation, develops in coherence with the theoretical framework provided by Simon (2009).

7 CONCLUSION

In this research, we observed and analyzed a community located in Hauts-de-France region, gathered in a Riot collaborative room and mobilized in to produce face shields during the first pandemic. This research is based on a double qualitative approach. The first is based on the exchanges in an online discussion space. The second is based on a set of interviews conducted with selected participants in this discussion space. Five people were identified for their role, commitment, expertise and/or involvement in conflicts. It leads to two contributions. On the one hand, we were able to propose a research methodology combining the quantitative analysis of online communities with the qualitative analysis of messages and the conduct of interviews. On the other hand, we were able to better understand the coordination, contributions and the profile of the mobilized makers.

The main limitation of this research is its localized nature. The analyzed discussion space concerns the Hauts-de-France and is strongly focused on the Lille region. Moreover, created and above all fed by institutional makers, it does not allow us to deeply analyze the organization of pure (isolated) makers in the face of the pandemic.

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REFERENCES

[1] Anderson, C. (2007). La longue traîne. Village mondial.
[2] Bobillier-Chaumon, M. E., & Dubois, M. (2009). L'adoption des technologies en situation professionnelle: quelles articulations possibles entre acceptabilité et acceptation?. Le travail humain, 72(4), 355-382.
[3] Cabanel, C. (2020), Covid-19 : à Lille et en région Hauts-de-France, des makers en première ligne, Makery, 7 juillet 2020 ; en ligne : https://www.makery.info/2020/07/07/a-lille-et-en-region-hauts-de-france-des-makers-en-premiere-ligne/ (consulté le 01/03/2021).
[4] Capdevila, I. (2015). Les différentes approches entrepreneuriales dans les espaces ouverts d'innovation. Innovations, 48(3), pp. 87-105.
[5] Chalet, L., Dutilleul, M., Fages, V., Gayoso, E. (2021). Des visières à haut débit : un regard sociologique sur la mobilisation des makers face à la crise sanitaire. Annales des Mines, n°14, juin 2021.
[6] Chignard, S. (2021). L'open data de crise : entre mobilisation citoyenne et communication gouvernementale. Annales des Mines, n°14, juin 2021.
[7] Cohendet, Patrick, Grandadam, David and Suire, Raphaël (2021). Reconsidering the dynamics of local knowledge creation: Middlegrounds and local innovation commons in the case of FabLabs. Zeitschrift für Wirtschaftsgeographie, vol. 65, no. 1, 2021, pp. 1-11.
[8] Desson, Z., Weller, E., McMeekin, P., & Ammi, M. (2020). An analysis of the policy responses to the COVID-19 pandemic in France, Belgium, and Canada. Health Policy and Technology, vol. 9, pp. 430-446.
[9] Dubois, M., Bobillier-Chaumon, M.-E. (2009). L'acceptabilité des technologies : bilans et nouvelles perspectives, Le travail humain, 2009/4 (Vol. 72), pp. 305-310.
[10] Fauchart, E., Rayna, T., Striukova, L.: Is selling caring? Norms regulating commercialisation and sharing behaviour with the open hardware RepRap. Proceedings of the "XXVIème Conférence Internationale de Management Stratégique" (AIMS), Lyon (France) (2017).
[11] Grandadam, D., Cohendet, P., & Simon, L. (2013). Places, spaces and the dynamics of creativity: The video game industry in Montreal. Regional studies, 47(10), 1701-1714.
[12] Hansen, D., Shneiderman, B., & Smith, M.A. (2010). Analyzing social media networks with NodeXL: Insights from a connected world. Morgan Kaufmann.
[13] Kera, D. (2015). Open source hardware (OSHW) for open science in the global south: geek diplomacy? Open Science, pp. 133-156.
[14] Leclercq, E. & & Savonnet, M. (2018). Modèle tensoriel pour l'entreposage et l'analyse des données des réseaux sociaux. In INFormatique des ORganisation et des Systèmes d'Information et de Décision (INFORSID), pp. 93-108.
[15] Lejeune, C. (2014), Manuel d'analyse qualitative, De Boeck.
[16] Miner, G. & al. (2012). Practical text mining and statistical analysis for non-structured text data applications, Academic Press.
[17] Pénin, J. (2011). Open source innovation: Towards a generalization of the open source model beyond software. Revue d'économie industrielle, (136), 65-88.
[18] Simon, L. (2009). Underground, upperground et middle-ground: les collectifs créatifs et la capacité créative de la ville. Management international, 13, 37-51.
[19] Somers, S. (2009). Measuring resilience potential: An adaptive strategy for organizational crisis planning. Journal of contingencies and crisis management, 17(1), 12-23.
[20] Suire, R. (2016). La performance des lieux de cocréation de connaissances. Réseaux, (2), 81-109.
[21] Troxler, P. (2014). Fab Labs forked: A grassroots insurgency inside the next industrial revolution. Journal of Peer Production, 5.
[22] Utterback, J.M. (1994). Mastering the dynamics of innovation, Harvard University Business School Press, Boston Massachusets.
[23] Viseur, R. (2014). Automating the Shaping of Metadata Extracted from a Company Website with Open Source Tools, International Journal of Advanced Computer Science and Applications(IJACSA), Special Issue on Natural Language Processing.
[24] Viseur, R. & Charleux, A. (2021a). Open source communities and forks: a rereading in the light of Albert Hirschman's writings, Open Source Systems 2021.
[25] Viseur, R. & Charleux, A. (2021b). Contributions et coordination des makers face à la crise du COVID-19, Terminal, n°130.