



Article

Open Innovation via Crowdsourcing: A Digital Only Hackathon Case Study from Sweden

Serdar Temiz

Industrial Engineering and Management Division, Uppsala University, 752 37 Uppsala, Sweden;
serdar.temiz@angstrom.uu.se or temiz@kth.se

Abstract: This paper explores HacktheCrisis, the Swedish hackathon that was a response to the COVID-19 pandemic to address the challenges that it brought up. The main aims of the research were to explore the feasibility of the digital only COVID-19 hackathon as an open innovation method and to uncover the major issues that emerged during the HacktheCrisis hackathon in Sweden. The process and outcomes were assessed, leading to the lessons and development of recommendations for future health hackathons as an innovation in health care. We have found that conducting the virtual hackathon for COVID-19 resulted in significant growth in the digital health community in Sweden. Governments should be as fast as the private actors and citizens to address these challenges and to undertake organizational adaptations. Not only the hackathons, but the projects and processes after the hackathons should also be planned. Matchmaking between individuals and private and public actors should be facilitated throughout the year. Technology companies should provide platforms that facilitate flow of process with nice structures and user-friendly tools. Organizations were not ready to utilize the outcomes of these hackathons. Compared to public organizations, private organizations were faster to join hackathons.

Keywords: hackathon; COVID-19; crisis; Sweden; open data; open innovation; crowdsourcing



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1. Introduction

“Would you like to make a difference in the time of the COVID-19 outbreak? We can save thousands of lives when we unite! Let's hackathon!”

Statement at Bio of Hackthecrisis Twitter Account

National and global hackathons promote a range of interdisciplinary challenges to address local and global challenges such as climate change, criminal justice, democracy, health care, and space [1]. Even though these challenges require attention, one of the immediate challenges that humanity faces is adaptation to COVID-19. The coronavirus disease of 2019 (COVID-19) reportedly has infected more than 72,000,000 people, so far causing 1,600,000 deaths. The rapid spreading of the virus also means these numbers are increasing day by day. It has tremendously influenced the daily personal and work lives of everyone. This paper explores the Swedish hackathon, HacktheCrisis, response to the pandemic to address the challenges that COVID-19 brought up. The pandemic of the new coronavirus, COVID-19, is challenging every aspect of life. Daily lives are affected and what was once considered as “normal” has been put on hold and lives, health, businesses are threatened. This research explores the COVID-19 hackathon HacktheCrisis in Sweden.

2. History and Theoretical Background

The word hackathon is a synthesis of two words—hack and marathon. The first hackathon was held as an invite only event by the OpenBSD community in Calgary in June 1999 [2]. The event was invite-only and for only technical people. During the decades the concept has spread, and there are hackathons in many countries across many industries. Hackathons have different variations, with focuses ranging from software to hardware,

social projects to business projects. It has also been done in the medical sector, for example, the Open Bioinformatics Foundation, a nonprofit organization devoted to developing open-source software for the biological research community, held its first hackathon as early as 2002 [3]. There have been previous studies on health hackathons in different countries in Srilanka, Germany, Taiwan, China, Pakistan, which are explored and analyzed [3–7].

In recent years, the necessity of decentralize interdisciplinary teams to address the challenges facing society has become more and more apparent. People with diverse perspectives, skills and resources gather together in a short time to address the collective action problem that society faces. The Internet and connected worlds provide opportunities to democratize innovation, thus many ideas that are related to new products and services are no longer generated in well-financed government or corporate laboratories [8]. Instead, the ideas tend to come from almost anywhere and anyone. These efforts are nowadays observed in the public, where thousands of individuals participate to solve innovation related problems and provide a way for companies to leverage their innovation efforts internally.

2.1. *CrowdSourcing*

One approach adopted in utilizing open innovation is crowdsourcing, which is the term coined by Jeff Howe. Consistent with the open innovation paradigm, crowdsourcing can help the reduction of R&D costs, sharing of the risks of innovation, and it can increase the speed at which new innovative products and services are brought to the market since it allows easier access to a wide variety of skills, know-how, and expertise [9].

According to Howe, crowdsourcing is an act by which a task that is once performed by an employee is outsourced to a large and diverse group of people who are external to the company in the form of an open call [10]. Crowdsourcing happens when a digital platform is used by the company to utilize the power of the crowd as external labor (knowledge) resources instead of using its own internal employees [10]. Crowdsourcing appeals to companies because of several factors like lower labor cost, lower overheads and administration combined with the lack of regulation for employment, and social security [11]. There are different categories of crowdsourcing: crowdvoting, crowdfunding, crowdcompetition, crowdtasking, and crowdsearching. This is not an exhaustive list since the uses of a ‘crowd’ to perform a task or address a challenge have expanded in several other domains.

It is important to add, even though the term was coined in 2006, crowdsourcing is not something new. One of the old examples is creating the Oxford English Dictionary [12]. In 1857 the “Unregistered Words Committee” was formed by the Philological Society of London to collect unlisted or undefined words lacking in the dictionary available during their period. In 1857 the committee realized that if the words collection be given to volunteers, they can supply works, usage and reference by reading books. The Oxford English Dictionary still utilizes crowdsourcing to find earlier records of a word that their editors are currently researching [13].

Another example is in 1714 during the reign of Queen Anne, being a challenge driven competition conducted to find the Longitude of ship at a sea with a prize amount of £20,000 which is called The Longitude Prize, and the act passed was called the Longitude Act [14]. The Longitude prize is still active and currently The Longitude Prize will reward the team of researchers with a £10 m prize for the research team which develops a point-of-care diagnostic test to conserve antibiotics for future generations [15].

Modern companies have utilized crowdsourcing as well. Starbuck’s MyStarbucksIdea and Dell’s IdeaStorm are continuous and ongoing crowdsourcing communities where people are asked to keep submitting ideas and that might help improve the company’s product or services.

From a network perspective there are four types of configurations of innovation crowd-sourcing available to firms and organizations, namely (Figure 1): internal crowdsourcing, community crowdsourcing, open crowdsourcing, and crowdsourcing via a broker [9].

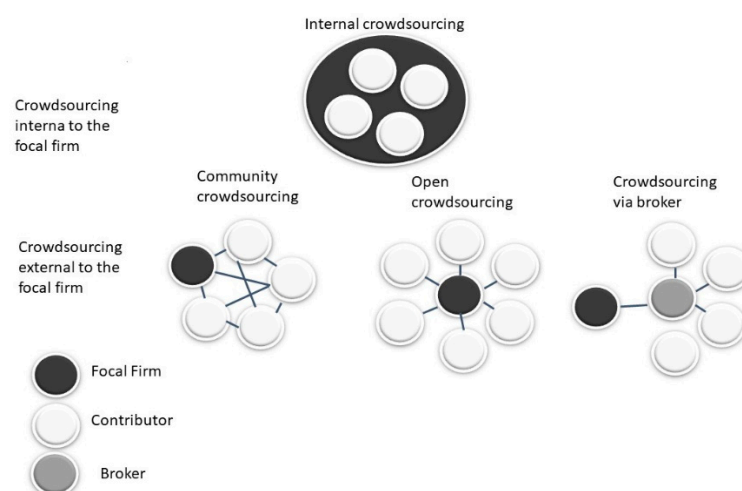


Figure 1. Categorization of configurations for innovation crowdsourcing (adopted from [16]).

In the first configuration, the focal firm is connected to all its employees [9] and the idea is to leverage the expertise and heterogeneous knowledge of an industrial firm's employees [16].

The community crowdsourcing presents a densely connected network, and the involved actors are the focal firm and the contributors, preselected on the basis of specific resources or required knowledge [9]. This type of crowdsourcing is aimed to tap in the expertise of densely connected networks of experts working on a specific topic or challenge [16].

In the open crowdsourcing, the network configuration is star-shaped and the focal firm is connected to potentially unlimited contributors, without any form of preselection, [9]. Open crowdsourcing aims to gain access to the brightest of ideas by involving as many actors as possible in the innovation challenge and making it as easy as possible for any actor to contribute [9].

Crowdsourcing via *innovation intermediaries*—or innovation brokers configuration— involves the focal firm to be connected to a broker, who is then connected to potentially unlimited contributors [9,16].

2.2. Hackathon

The hackathon is also a model of crowdsourcing with the goal to utilize and stimulate innovation among groups with diverse backgrounds that learn from each other, share knowledge and work toward a common goal [17,18]. Other features of the hackathon model can be listed as “focusing on a specific problem, developing a solution via design thinking techniques, pitching the solution to participants, gathering rapid feedback and quickly altering the prototype design” [17].

Hackathons are referred to with different names including, but not limited to, codefest, hackfest, codesprint and design sprint [18]. While the majority of these hackathons are focused on software development, some also focus on hardware development [18]. Due to limited resources, these hardware developments do not usually go beyond initial simulation or emulation [18]. Hackathons can be categorized as tech centric or focus centric. Research on hackathons in Europe is rare and the recent example is on a hackathon in Germany [7].

Thus, with the topic of COVID-19 in mind and with limited research to serve as a reference point, this research aimed to conduct a case study of a hackathon on COVID-19. We endeavored to answer the following research questions: (a) How is it possible to engage individuals in a hackathon focused on an immediate challenge like COVID-19 (who attends and why)? (b) What is the experience of attendees and what are their suggestions for improving the experience? (c) How can engagement to a civic hackathon be increased? (d) It is known that long-term collocation helps advance technical work and facilitate

collaboration, but can similar benefits come from brief, hackathon-style collaboration for COVID-19 types of challenges, and how?

2.3. Research Context

The HacktheCrisis movement started in Estonia, where the first hackathon was run between 13–15 March in 2020, in collaboration of Garage48, AccelerateEstonia, the startup community and the Estonian government to take action and put together an online hackathon to offer solutions on how to use tech for crisis response and to deal with the post-crisis era [19]. The Open Innovation approach has been used to address COVID-19 challenges in different countries and domains [20]. Several countries around the world are following in their footsteps to bring all good forces together to beat this pandemic. By the date of the paper submission, there have been 67 hackathons confirmed and the number is growing. Sweden's public and private sector has put efforts to create an ecosystem to address several public challenges by open data hackathons [21]. It was the 26th of March, 2020 when Sweden's Agency of Digital Government (DIGG), in conjunction with Hack for Sweden, Openhack and The Swedish Government announced that they would host a virtual hackathon around the challenges the COVID-19 brought up and the data for the hackathon was collated between 3–6 April. Solutions could range from critical resources to support for the people isolated. There were 130 partners, 200 mentors, and a total of 7439 participants during this hackathon.

Open Hack is a volunteer based organization which provides a platform for collaboration for tech-volunteers to address local and global challenges with open source software as the main kit. Hack for Sweden started in 2014 as a citizen driven hackathon where public and private organizations could join forces to create new tools and services based on open datasets [22]. The initiative has grown significantly under the Swedish Public Employment Service's management and today creates valuable links between over 100 different public and private organizations in Sweden's innovation ecosystem. DIGG, was founded on the 1st of September, 2018; it took ownership of Hack for Sweden in 2020 and their first hackathon became HacktheCrisis.

HacktheCrisis in Sweden, by the time of the submission, due to its highest number of participants both locally and internationally, makes a unique case to explore.

3. Research Methodology

Since the research is a qualitative exploratory case study, it does not carry any particular hypothesis or proposition with it. Case studies are particularly useful when studying contemporary phenomena, when the investigator has little control over the events and when "how" or "why" questions are being posed [23]. Yin (2003) also states that case studies are useful since they offer direct observations and interviews with the event participants. HacktheCrises has been chosen because its unusually revelatory, extreme exemplars [23].

This case study analysed the preparation, process and performance of a multidisciplinary and multinational virtual COVID-19 hackathon conducted in Sweden. In this paper, we outline Sweden's unique experience and perspectives with COVID-19 hackathon innovation competition and describe the issues and challenges in hosting this type of event.

3.1. Data Collection

Using a case study design, several sources of data were used to understand event participants' experience. Qualitative data is collected from both primary and secondary data sources. These sources of data were triangulated to understand the event from multiple perspectives. Each data source is described in greater detail next (see Table 1).

Table 1. Data Sources.

Data Source	Notes
Slack Channel	all chat logs at hackathon communication platform, slack
Hackathon website	information website of HacktheCrisis of Sweden https://www.hackthecrisis.se/
Submission Platform	Challenge submission platform www.guaana.com
Field Notes and Observations	A researcher joined the hackathon as observer and took field notes for observations
Interviews	10 semi structured interviews with 5 project organizers and 5 hackathon participants from public and private sector (Table 2).
Webinar video	Webinar is co-organized by Nordic Innovation House Singapore and the UNDP Singapore Global Centre for Technology, Innovation and Sustainable Development. Ann Molin, Head Project Manager of HacktheCrisis of Sweden, shared her knowledge and experience with other representatives from Singapore, Finland, Iceland, Norway, and Sweden
Linkedin Posts	Linkedin posts of hackathon organizers (Carolina Emanuelson, Ann Molin, Jasmin Elmi)

Table 2. Interview list.

Name	Role	Date	Organisation
Carolina Emanuelson	Partner Manager	27 April 2020	Hack For Sweden
Sven-Erik Ceedigh	Senior IT Specialist	08 May 2020	Digg
Jasmin Elmi	Operations Manager	08 May 2020	Hack For Sweden
Oscar Mörke	Community Manager	08 May 2020	Hack For Sweden
Ann Molin	Head Project Manager	11 May 2020	Hack For Sweden
Ebba Theding	CFO	11 May 2020	Chromaway AB
Participant 1	Technical	11 May 2020	Private sector
Participant 2	Technical & Business	11 May 2020	Public sector
Participant 3	Project Manager	13 May 2020	Public sector
Participant 4	Developer	29 May 2020	Private sector

All interview and data collection procedures were applied consistently, including the preparation of interviews and open ended semi-structured questionnaires, data collection, and analysis. Chats at slack channel are copied to word documents and then analyzed.

The interview technique was a semi structured open-ended interview. The purpose of a semi structured open-ended interview is to avoid unintentionally guiding the interviewee into a predefined answer. The questions are made general enough to leave room for participants to address issues they wanted to mention. For Linkedin posts, posts of Carolina Emanuelson, Ann Molin, Jasmin Elmi were collected since these organizers were actively sharing information, invitation, and numbers regarding the event.

All the interviews were recorded via zoom software. During the interviews, written notes were also taken to cover the most important answers. In addition, an interview diary was kept during the entire interview process to shelter more general thoughts from each interview. After the interview process, the recorded interviews were analyzed. The interviews were conducted between 27 of March and 13 of May 2020. All interviews were done via Zoom software, and the follow up questions were raised via Linkedin platform. Each interview took between 19 min to 55 min.

3.2. Data Analysis

The interviews and data collected in this study were recorded and transcribed, to enhance reliability. Extracts from interview data were presented to increase reliability. The coding procedure also provided the opportunity to check and control interview participants' answers and hackathon participants' discussions at slack channel at any point during analysis; when something was unclear, interview participants were contacted and slack channel discussions were checked for clarification, or verification. In this study, to address reliability, two researchers separately coded transcripts, comparing, and modifying by discussion to reconcile them and arrive at a final version [24].

Inductive research lacks a generally accepted model for its central creative process [25], p. 46. In the absence of a common model, this research used the following method: qualitative content analysis method was adopted where coding categories are derived directly from the text data and we evaluated patterns within the content. QDA Miner lite software package was used as a computer-supported qualitative data analysis tool; while two researchers performed analysis, QDA Miner lite used as a digital note-taking tool and for categorization. Initial coding of the data produced over 100 codes, and by constantly reviewing and comparing these codes to what interview and competition participants stated, redundancies and potential overlaps in the codes were gradually removed. During this process codes transformed into suggested, but not definitive, themes and were either merged or changed to reflect more concisely what was said. The final list consisted of 80 codes, which are often referred to as "first-order concepts". Those codes were then assigned to 18 second order themes, which essentially combine codes with a common topic into a single group as 6 final themes.

3.3. Technical Platform

In addition to HacktheCrisis website, Guaana and slack are used. Guaana is a community-based web platform to run online innovation and research challenges and it was founded in 2014 in Estonia. Hackathon participants are asked to submit their solutions to the platform. Slack is a commercial real time chat communication and file sharing platform that has removed limitations for projects addressing COVID-19.

Both platform are selected since first Hackathon organizers used both and the Swedish team decided to listen their recommendation.

3.4. Goal and Objectives of Hackathon

The major driver behind HacktheCrisis Sweden was to promote inclusivity of all "We want to include everyone in solving this crisis, also those who cannot code". The goals behind HacktheCrisis Sweden were:

- To bring together a diverse group of developers, data scientists, makers, business analysts, university students, and clinicians to collaborate and explore the next generation of connected devices to identify and solve major health related problems
- To expose participants to concepts of design thinking and global health informatics as well as the technical skills required to develop mobile health tools and platforms
- To demonstrate the complexities of the clinical thought process and the factors that drive quality improvement
- To support practical hacking sessions using existing open-source tools

Hack the Crisis Sweden challenges were divided into three challenges and the participants could choose either of two tracks to provide their solution. Three challenges are presented: save lives, save communities and save businesses (see Table 3).

Table 3. Challenges at HacktheCrises.

Challenges	Description
Save lives	While medical experts are trying to find a vaccine and cure for the virus, are there other (direct or indirect) solutions that can help people to stay safe?
Save communities	People are encouraged to have physical distancing. How could communities maintain physical distance but at the same time have community and be in solidarity? Can we create some digital tools to manage that?
Save businesses	How can businesses mitigate challenges COVID-19 has brought up? Are there new revenue streams that can be created in a limited time? How can we ensure that businesses can survive during and after COVID-19?

There were two tracks wherein participants could provide their solution: “digital solutions” and “concepts”. The digital solutions track was similar to other tech hackathons wherein the IT team builds a digital product, prototype, service, or app (code included) that is considered as functional enough to be a minimum viable product that can be developed and used within two months. Digital products must be presented as a demo or as two minutes of video recording. The concept solutions track was for the teams unable to develop a tech solution (due to missing skills, in this case coding) or that could not solve a problem without involvement of a government. Government agencies might provide data or resources in terms of financing in order to utilize conceptual solutions that address one of the challenges of COVID-19. Instead of code submission, teams are expected to create a 7-page slide in PDF format that describes their solution to a problem.

3.5. Hackathon Preparation

The theme of the hackathon was chosen to be specific, on the one hand, to focus on solutions related to challenges that COVID-19 created and, on the other hand, to be as broad as possible to include participants from the public sector, private sector, academia, non-profit organizations, and citizens are all invited to participate. In order to do that, for each challenge category the “concepts” track is included to motivate non-technical people to participate.

In order to reach a wide multidisciplinary community that included public sector, private sector, academia, non-profit organizations, and citizens are all invited to participate, partners asked to release targeted announcements prior to the event via social networks: LinkedIn, Facebook, and Twitter. Organizing team also reached out to existing Hackfor-Sweden, OpenHack and other networks. During promotion of the event, in order to show support of the Swedish government, the government and DIGG issued separate press releases to show support for the event.

The barriers to being a partner were low, partnership was free of charge, but partner organizations were asked to support either or several of these supports for the hackathon: (a) prize(s) to winning teams, tools for the hackers (tools, open data, credits, etc.), (b) mentors (key competencies valuable to the hackers), (c) incubation program and/or go-to-market support, (d) hackers from their organization who would like to join the hackathon.

In addition to tackle a global challenge and having the whole hackathon virtual, another uniqueness for this event was having specific stakeholders so that solutions could be taken care after the event.

The National Board of Health and Welfare, Swedish ehealth Agency, Municipality of Lund, Stockholm and Gothenburg were stakeholders.

3.6. Hackathon Process

It was run between 3–6 of April. There was only one read-only communication channel #announcements where all communication is done by Jasmin Elmi. When Elmi wrote on this channel, it meant it was something important about hackathon.

Slack has many features, but the organizer team put hard restrictions at slack features and features are unlocked step by step as necessary and requests arise such as creating their own chat channels. The organizer team only sent three emails, main communication was via announcement channel at slack.

Ninety-five jury members in six jury groups had 12 h to pick winners. The jury head was asked to provide feedback to each team.

4. Hackathon Results and Analysis

In total there were 7439 participants from 91 countries, 130 partners, 200 mentors and 95 jury members. Some mentors were also provided by partners. There were people across the sectors, with different skillsets and ages. Some of the participants stated that it was their first ever hackathon. Participants created user groups, slack channels, and shared files among each other.

At slack, there were 35 user groups ranging from 1 member to 69 members where the largest group was from VOLVO corporation, followed by Dekuri Solutions (see Appendix A).

There were 24 digital communication channels at slack ranging from 6488 to 4 members in the channel. 4 of the channels had no chat, even though they were created. The most active channels were, respectively, #announcement (6488 members), #random (6456 members), #ask-organizers-for-help (4425), #team-creation-post-ideas (1506 members), #team-creation-post-skills (1187 members, #resources (791) followed by 3 channels with challenge names #save-lives, #save-communities and #save-communities with 720, 680 and 662 members, respectively (Table A2, Appendix A).

In total 361 files were shared via slack channel, where the majority of shares were images (261), followed by 24 videos and 54 presentations (Table A3, Appendix A).

4.1. Results

Jury members considered realizability, benefit for society, scalability, and comprehensibility during the judging process. The jury selected 60 finalists to be listed at the HacktheCrisis website where 10 solutions/teams are listed for each category and track. The winners are listed in Table 4.

Table 4. Winner list.

Winner Project	Category
Remote + gigs on 'platsbanken'	Concept—Save Business
Coronafree	Concept—Save Communities
Protective Visor	Concept—Save Lives
BreakEven	Digital—Save Business
Telehelp—Bridge the Digital Divide	Digital—Save Communities
VoiceMed	Digital—Save Lives

These are descriptions of each solution:

Remote + gigs on 'platsbanken': The winning case is a solution that speaks directly to the remote work and gig-economy that a big part of Swedish businesses are made up of today, that provided a solution for remote gigs on the platsbanken-job portal of the Swedish Public Employment Service.

Coronafree: This project aims to identify and enable those who get back into society and to their everyday lives.

Protective Visor: With this solution, health care and social care personnel can be supported since the solution is fast, simple, and at a low cost.

BreakEven: It is a solution that creates an interface that could visualize exactly how much help a business needs in real-time. Customers then get a definite way to act and help the community to "break-even".

Telehelp—Bridge the Digital Divide: This solution is to address the challenge for communities to continue operating, communicate to their citizens and organizations, and promote social solidarity. The winning team's solution is easy to use for the elderly specifically, and brings those in need of help together with volunteers.

VoiceMed: This service provides health diagnostics via phone call or voice recording and this service promises a huge strain off the existing medical support services and tackles the lack of available testing, by providing an ingenious yet simple technical solution that can easily be used by anyone of any age, and regardless of access to the internet.

4.2. Analysis

We identified that six main themes emerged from the data: (1) setting ground rules and collaboration; (2) challenges in inclusion of public sector; (3) importance of the challenge and challenge owner, (4) feedback and appreciation, (5) ambiguity of process after hackathon; (6) importance of hackathon tools and hackathon organizing team. The findings presented that utilizing digital platforms to have a digital only hackathon to address COVID-19 challenges was a feasible model for open innovation with several areas of improvement. These areas are described within themes. Each theme is summarized below:

4.2.1. Setting Ground Rules and Collaboration

All the project team was active at the slack channel, but the main active person was Jasmi Elmi. As Carolina Emanuelson stated, the team had to be *"very good at moderating at online one and keep engagement; you need to answer people, send them emojis"* so that participants could engage and also immerse themselves in the hackathon and see someone answers their question. Participants were encouraged to answer each other and help each other. They were warned to be nice to each other and reminded that thousands of people can reach each other. Since there were initial restrictions and a read-only announcement channel that communicated ground rules, it facilitated collaboration and a constructive environment.

4.2.2. Challenges in Inclusion of Public Sector

Private organizations were able to respond and join the hackathon immediately with more numbers, but it was hard to get public organizations to join. Participant 4 stated that *'We had to make decisions that were decisions we usually would not make when it comes to it and even that takes months'* as Ann Molin further elaborates on the issue:

"Private sector does not have a format for forming partnerships" (whereas in the private sector) "always somebody who is in charge of partnership, that person has authority to sign partnership agreements with other organizations. Forming a partnership with a private company can take two days or up to a week but with a government agency or municipality it takes months".

Ann Molin also states that they had a similar experience with Hack for Sweden in prior to hackathons. One of the reasons could be that they were occupied with the current crisis and another issue, as stated by public sector participant 2, that participants had no idea how to be part of it. This can be an indication that, even though organizers tried to reach out to the public sector, the communication was lost and did not transmit to public sector employees.

4.2.3. Importance of the Challenge and Challenge Owner

As stated in the result section, the winning case of Save Business aims to solve a problem, raised by the Swedish Public Employment Service at this hackathon. This is an example of how a concrete problem might lead a team to address that problem. On the other hand, one of the public sector employees was actually looking for a solution that was provided by one of the teams (Chromaway AB) but during the interview it was noticed that, participant 2, did not run into this company or hear about their solution.

As stated by the interview participants, there was lack of participation from the public sector, which shows that there is a lack of communication and co-creation between a municipality and developers resulting in insecurity in regards of the future of the services [26].

This hackathon, by having the largest number of participants from the private sector, VOLVO specifically, shows that, when there is a strong reason and strong call, some of the private companies are eager to collaborate with public sector and citizens, with the condition that joining as partner does not have high barriers.

4.2.4. Power of Solidarity

It also should be noted that OpenHack was planning to hold a hackathon independently at the same time but when a request came from Ann Molin to collaborate, instead of doing a separate event, they decided to join their forces. It is also noticed that, during the hackathon, teams were not acting like they were competing to win but mainly to provide a solution to address the challenge. Some startups were there to adopt their solutions to COVID-19 hoping that they could meet the stakeholders, but when asked, they did not care about winning but mainly to contribute. Ann Molin stated that this *“generosity and willingness to help out exceeded our wildest imaginations”* during the interview.

4.2.5. Feedback and Appreciation

Some teams were not happy for not receiving feedback or input for their work, as Participant 1 stated, *“We wanted to get direct feedback from governmental institutes”* and some thought their time was also not valued, as many credits were given to partners and mentors but not enough to participants. On the other hand, they also understand the emergency of the problem and problems that occurred during organization and do not mind these.

Almost all people were mainly using their real names but during live stream people could comment anonymously in real time, it seems some participants were not happy for the frequency of appreciation to jury, mentors and partners, therefore they were anonymously commenting as *“thank you jury”* repeatedly. Since all participants put in their weekend and time voluntarily, there needs to be balance between who you credit and who you thank. Organizations should focus on thanking hackers and participants more than jury members.

4.2.6. Ambiguity of Process after Hackathon

The main work starts after the challenge, to make things created come to reality. All teams put in a lot of effort, considering the diversity of projects and limited time, not only for the winning team but for all teams, there should be matchmaking and support process. Even though it is stated that stakeholders will keep in touch with projects, there is no clear process and description in place, and everything is left to be done voluntarily by stakeholders. Carolina Emanuelson stated that:

“Some stakeholders did not know how to include solutions in their organization with the existing structure. Some of them have already been working on similar solutions “

This was also echoed by other participants who explained that their challenge had to reach the right organization and the right people inside the organization. It can be said that, not only matchmaking but also incubation support and organizational change within public and private organizations should take place to utilize solutions from COVID-19 hackathons.

4.2.7. Importance of Hackathon Tools and Hackathon Organizing Team

Oscar Mörke stated that the team had actually 3 h of time to choose the right platforms and that they had to rely on previous COVID-19 hackathons' experience. The time restriction and limited availability of tools provided limited options. As a result, Slack and Gyaana.com were picked to use during hackathon. Based on our observation during hackathon and as well as comments during participant interviews, slack channel was too crowded from time to time, where it made it difficult to follow up the communication.

Guaana.com crashed and the schedule had to change due to that. Proper and scalable platforms should be used. There was one landing page where participants could register, then they were asked to register to slack and then automatic email for the toolbox such as amazon resources and guidelines. All the flow from registration to find resources and mentors was perceived as confusing and not considered as efficient. The whole process should be coherent to provide a better experience.

The organizing team was able to organize this type of challenge because they had previous knowledge of both the process and each other and they worked independently. As Molin stated when the task was assigned to them, she asked to bring her own team that she knows well because forming a new team and getting to know them takes too much time. Molin stated that *"If you know the people you work with, you work very fast, you can be blunt and direct, and they can also be direct"*.

5. Discussion: Hackathon and Open Innovation in Sweden

This research's aim was to determine whether it was feasible to gather interdisciplinary teams to learn about and develop solutions during a hackathon for a particular immediate challenge, in this case, for COVID-19. Furthermore, we also asked those we interviewed to share their reasons to participate, benefits and challenges on participating and suggestions on how to improve the outcomes of the hackathon experience. In addition, we followed the way organizers and participants communicated. The process and outcomes were assessed, leading to the lessons and development of recommendations for future health hackathons as an innovation in health care. It can be concluded that, conducting the virtual hackathon for COVID-19 resulted in significant growth in the digital health community in Sweden. Even though there are benefits from brief hackathon-style collaboration, it can only be the starting point for further collaboration. Governments should be as fast as private actors and the citizens to address these challenges and do organizational adaptations. Meticulous regulations and vast bureaucratic procedures within the public sector may hinder public organizations from collaborating with external organizations [27]. There have been commercial companies joining the hackathon, and public organizations publicly sharing their challenges and limitations. Even some private companies encouraged their employees to join the hackathon, to find nice solutions or to contribute to finding nice solutions. It can be said that selectively opening innovation processes might lead a new competitive advantage for organizations [28]. Not only hackathons but projects and processes after a hackathon should be also planned. If the process after a hackathon can be managed properly to match hackathon solutions with existing organizations to address customer needs, then the value of having hackathon can be more evident. Furthermore, if it can be managed to connect developed solutions to the markets, open innovation via hackathons can be a starting point of creation of new start-ups and Small Medium Enterprises (SMEs) [29]. Matchmaking between individuals, private and public actors should be facilitated through the year. Technology companies should provide platforms that facilitate flow of process with nice structures and user-friendly tools. Organizations were not ready to utilize outcomes of these hackathons. Compared to public organizations, private organizations were faster to join hackathons. Our findings match with the research that managing external relations with external actors requires a dedicated organization team [30]. Organizations should reform their structure and able to utilize outcomes of these hackathons. Organizations and the government should introduce new policies to reform their structure, to coordinate next steps after hackathons for incubation, matchmaking and introducing to the market.

6. Limitations

There was a very limited time to meet participants since some hackathon participants were joining follow up hackathons and events such as the *EUvsVirus* hackathon. In addition, public sector employees were occupied to address the challenges caused by COVID-19 and private sector employees were also occupied to address the challenges that they faced.

Therefore, the research was conducted with a limited number of interviews, but considering the amount of collected data, due to the nature of the case, which is exemplary, it can be said that major themes were found. Another limitation is the vibrant changes and activities during the research period, which might only have let findings be snapshots of particular events and might limit generalities.

7. Future Research

Several other COVID-19 related hackathons were organized in other countries. Similar research can be conducted in other countries to compare countries to explore and to map similarities and differences between countries. Quantitative research via survey results could also be a potential future research avenue.

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Appendix A

Table A1. Teams. Groups that did not have any chat or single chat by the creator are not listed Table A1.

Team Member Numbers	Number of Groups	Name of User Groups
1	9	No message here
2	4	No message here
3	5	No message here
4	5	No message here
5	4	No message here
6	1	No message here
9	3	PRV, Hygiene-Safe environments, connect and inform team
11	2	Samla Ehälsomydingheten, One Team Gov
12	1	Dekiru
69	1	VOLVO

Table A2. Channel List.

Channel Name	Date of Creation	Number of Members
*#announcement	25 March 2020	6488
#random	25 March 2020	6456
#ask-organizers-for-help	31 March 2020	4425
#team-creation-post-ideas	31 March 2020	1506
# team-creation-post-skills	31 March 2020	1187
#resources	31 March 2020	791
#save-lives	31 March 2020	720
#save-businesses	31 March 2020	680
#save-communities	31 March 2020	662
#looking-for-mentors	3 April 2020	435
#resources-open-data	2 April 2020	301
#ask-stakeholders	3 April 2020	271
#community-greetings	3 April 2020	257
#live-stream-schedule	4 April 2020	238
#going-forward	6 April 2020	192
#stakeholder-challenges	4 April 2020	110
#euvsvirus	20 April 2020	91
#peer-review	5 April 2020	36
#voicemed	11 April 2020	13
#remoteplusgigsonplatsbanken	11 April 2020	8
#telehelp	11 April 2020	7
#breakeven	11 April 2020	6
#coronafree	11 April 2020	6
#protectivevisor	11 April 2020	4

*# denotes communication channel at slack software.

Table A3. Number and Type of File Shares.

File Type	Number	Notes
Images	261	
Video	24	MP4
Presentation	56	51 PDF rest other (mind map etc)
Excel	2	
Snippets (json, xml)	4	Two files in different formats
Documents	4	2 googledoc 2 word
TOTAL	361	

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