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Bachelor's thesis:

The Online Hackathon

Typology of a Hackathon Format and its Potential Application in Citizen Science

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1. Introduction

1.1 Overview of the topic and goal of this thesis

Hackathons are a relatively young phenomenon in the techno-scientific event landscape. In the last couple of years, hackathons became more interdisciplinary, gender-balanced, and cross-functional, diminishing their image of events that are meant for geeks and nerds. Today, the hackathon is globally adopted in various fields by a wide spectrum of organisations (cf. Taylor & Clarke, 2018, p. 1). In modern hackathons, interdisciplinary teams work on a mutual project, aggregating wide and eclectic input from different perspectives. This leads to thought-out, sustainable, and creative solutions and innovations; here lies the big potential of hackathons. The most recent break in this constantly evolving field was its digitalisation. Induced by the Covid-19 pandemic, online hackathons gained extraordinary momentum. In several countries and under the patronage of the respective governments, non-governmental organisations (NGOs) organised nation-wide hackathons as a reaction to the coronavirus crisis. Their goal was to harvest collective intelligence for tackling challenges entailed by the coronavirus outbreak such as the protection of risk groups or the mitigation of health risks in public transport. These crisis-related online hackathons led to unprecedented occurrences regarding virtual public engagement: thousands of people from all parts of society and various backgrounds were collaborating online for the common good, facilitated by this new event format. This highlights another positive aspect of the online hackathon: next to fertile soil for ideas and innovation, the online hackathon offers large scale participation and eventually democratisation, empowering citizens to make a contribution in addressing issues that affect the whole of society (cf. Blumler & Coleman, 2001, p. 18).

From a scientific point of view, the online hackathon poses an intriguing object of research for sociologists, political scientists, economists, or science communicators alike. Given its remarkable potential for driving innovation and participation, the online hackathon embodies a new instrument many domains can benefit from. Its low-threshold accessibility in respect of location, time, technology, qualification requirements, as well as its scalability and relatively low costs, permits many fields of application for this new event type. While research on hackathons has grown considerably in the past couple of years (cf. Nolte, Chounta, & Herbsleb, 2020, p. 1), there have not been many investigations into the virtual adaptations to the hackathon concept. Despite the abovementioned benefits, in the past, online hackathons with the same time frame as their physical counterparts (48 hours) were

deemed as too complex and ineffective (cf. Kohne & Wehmeier, 2019, p. 38). Therefore, while there was the alternative of traditional on-site hackathons, a good concept to facilitate hackathons virtually has never been developed. The coronavirus pandemic, however, has set restraints to this alternative, and, at the same time, proved sceptics wrong. During 2020, many online hackathons were conducted in a 48-hour-timeframe (or similar duration) as it is the case for most physical hackathons. "While collocated teams, distributed teams, and open-source development have all received considerable attention in the CSCW literature, we do not know much about hackathons […] (Trainer et al., 2016, p. 1116)," consequently, even less is known about the online hackathon phenomenon in particular.[1] Although there are already some practical guides on how to organise a virtual hackathon event available on the internet, the online hackathon phenomenon itself has not been thoroughly examined on a theoretical basis. The online hackathon is on the rise yet has not been scientifically defined. There is some scarce research related to online hackathons to be found, almost all of it published in 2020. However, the already existing papers investigate rather specific questions around the general hackathon topic which also involve online hackathons, but not as the actual subject. None of those scientific papers provides a holistic, theoretical survey of the online hackathon phenomenon that describes its actual nature.[2] Taking that into account, the goal of this thesis is to provide some theoretical groundwork regarding the research on the online hackathon phenomenon and to highlight its potential.

Furthermore, this work aims to serve as a practical source of information, giving a basic introduction into the hackathon concept and its recent adaptation to online environments, providing food-for-thought for the reader, whose organisation might want to utilise the online hackathon format. On the following pages, the reader finds a first account on the online hackathon regarding its short history, characteristics, chances, and challenges, all in all providing an elaborate description of this particular event type. Additionally, potential applications of the online hackathon on citizen science are drafted. This shall serve as a concrete example, demonstrating the potential benefits this new virtual hackathon format offers to the field of science communication and the scientific community in a wider sense, which has already discovered on-site hackathons for its purposes (cf. Trainer et al., 2016, p. 1116).

[1] Computer Supported Collaborative Work (CSCW) is, as the name already suggests, the utilisation of digital, i.e., computer-based applications, enabling their users to cooperate. Examples for CSCW applications often used at hackathons are *Slack*, *Microsoft Teams*, or *Mattermost*.

[2] This refers to November 2020 and the best of the author's knowledge after examining major online libraries and platforms that list scientific publications like *Google Scholar*, *SAGE journals*, *ResearchGate*, etc.

1.2 Research approach and limitations

As mentioned, online hackathons are a relatively new phenomenon and thus widely uncharted. This brings along advantages and disadvantages to research in this domain. One downside is the lack of points of reference and orientation; not being able to consult extensive primary literature or datasets on online hackathons can render the approach rather vague. On the other hand, the advantages of not having a pre-defined baseline provide a vast extent of freedom to the framing of this work. These factors must be kept in mind regarding this thesis. Having been involved in the organisation of four online hackathons thus far, the author was able to form solid background knowledge and gather experience in this recent field. To make this work comprehensible, factual, and transparent, the aim is to strike a balance between subjective observations and assessments as well as objective sources of information. This includes the record of the author's own observations and the observations of his fellow hackathon organisers, the scientific literature and analogies regarding (physical) hackathons, scientific literature on similar domains in regard to virtual collaboration, information on online hackathons that can be found on their respective websites, as well as media coverage and other diverse sources, which shall all be documented. Taking the risks of subjective biases into account, these subjective observations and assessments – which occur in chapters 3, 4, and 5 – are elaborated and made comprehensible to the best of the author's abilities, aiming to mitigate any factual contortions and misconceptions. Furthermore, given the online hackathon is a form of online collaboration and an online learning environment, research results in those domains can arguably hold employable insights when applied to the online hackathon context. Hence, literature from these fields is incorporated in this work's composition, too.

The first step of this work is to give an overview of the event-type 'hackathon', briefly explaining its history and background, describing why those events are being held, highlighting their potential and usefulness, and referencing their current state of research. This provides the reader with basic knowledge about the hackathon concept and serves as a baseline for the elaboration that follows, which has the emerging hackathon format – the online hackathon – as its subject. In said elaboration, a typology of the online hackathon as a new format of the hackathon concept is furnished, which aims to serve as a foothold for further research and developments on the subject. Hence, the term *online hackathon* is defined, encompassing it from similar concepts, followed by a reconstruction of the recent developments in the field which have been sparked by the Covid-19 pandemic. Then the online hackathon's peculiarities and its technical prerequisites are described. Afterwards, its

characteristics are assessed, highlighting strengths as well as weaknesses. Eventually, based upon the elaboration of the online hackathon concept, use cases are inferred, illustrating the online hackathon's potential application in citizen science. It needs to be stressed that the purpose of this work is not to provide a step-by-step tutorial on how to organise online hackathons. Paradoxically, many of such 'online hackathon manuals' can already be found online, whereas, as already mentioned, theoretical accounts on the online hackathon's nature like this work are basically non-existent.

2. Overview of the hackathon phenomenon

2.1 The general hackathon concept

The portmanteau *hackathon* is combined with the words *hack* and *marathon*. The former refers to the English verb *to hack*, as in the sense of exploratory and investigative programming and not as a reference to committing a cybercrime (cf. Briscoe, 2014, p. 2). The latter, *marathon*, alludes to the event's ongoing and multi-day character. There are various synonyms for the term *hackathon* such as *hacking festival*, *codefest*, or *hack days* (cf. Briscoe, 2014, p. 3). However, some authors in hackathon-related literature might not consider these terms as synonymous. In fact, there appears to be no uniform and official terminology for hackathon-related terms, blurring their significance and making them somewhat ambiguous. In addition to that, there is also no holistic, uniform typology of the hackathon phenomena, which will be addressed later. In this work, the term *hackathon* refers to

> *a problem-focused event where people come together in a predefined time frame (mostly 48 hours) to work in small teams on novel ideas or technologies as well as challenges, creating something new and innovative.*

The ideas, technologies, and challenges to be hacked during a hackathon can either be presented by its organisers, or brought to the hackathon by the participants. In recent years, hackathons are attracting more and more people (cf. BeMyApp Agency, 2020). For their participants, they offer a great opportunity to learn new skills, meet new people, build up networks, win prizes, be creative and implement own ideas, get visibility, or simply have fun.

A hackathon usually consists of multiple sub-events, yet the agenda can differ depending on the hackathon type. Some hackathons offer a (mostly virtual) 'preparation phase' (also referred to as 'pre-hack phase') which allows participants to get familiar with each other and

their project before the actual event, enabling them to use the time – usually 48 hours – at the hackathon efficiently right from the start (cf. Trainer et al., 2016, p. 1125). The teams can be allocated by either organisers or participants themselves (cf. Kohne & Wehmeier, 2019, p. 21). The opening session marks the beginning of a hackathon. During this kick-off, the host welcomes the participants and recaps the event's modalities such as the topic, the goal, and the rules of the hackathon and, in many cases, there is a topic-related keynote talk. Then the teams pitch their projects to their fellow hackers and the interested audience. The hacking sessions, in which the actual work on the projects takes place, are loosely defined; in between the official gatherings, participants hack as long as they like. When teams are 'hacking' their challenge, they are trying to find creative, out-of-the-box solutions and innovations, usually having free choice of how to approach it. As the word *hack* implies, in the early days of hackathons, solutions were merely code-based. Yet the paradigm of solely tackling coding-related challenges during a hackathon has changed: the solution-finding process is now more open to other methods and, therefore, fields of applications. However, coding remains an essential tool and occurs in most hackathons. For example, during the hacking session, a team is working on an app. There are developers who manage the technical production (coding) of the app. Yet other team members with different skills look into UX (user experience) design, consider legal aspects, or take care of the business model and marketing strategies related to the app. If a team needs counselling on issues out of their field of expertise, usually, there are mentors and experts with various backgrounds available, not belonging to any team.

Along the course of the hackathon, in between the hacking sessions, there can be topic-related workshops, review sessions, or non-hacking-related socialising events like common meals, parties, or other fun get-togethers. At the end of the event during the closing, the teams present their outcomes which are mostly evaluated and awarded by a jury (cf. Kohne & Wehmeier, 2019, pp. 4–5). The jury usually consists of experts in the hackathon's topic of focus. Depending on the purpose of the hackathon, the closing, as well as the opening, can be made accessible to an interested audience or the wider public in general.

It is important to keep in mind that hackathons can hardly support the full development or implementation of a product or concept – mostly they serve as the kindling spark to kick-off a project (so-called 'seeding') or as brainstorming time for an already existing one. Depending on the participation motive of the team members, the team can decide after a hackathon to drive their project further. Hence, a considerable amount of work awaits the teams after the hackathon to further develop and eventually integrate their project, which

should be the goal of any hackathon project in general (cf. Nolte, Chounta, & Herbsleb, 2020, p. 2). For some hackathons, there are follow-up programmes to further support and foster the projects like an incubator or a mediation of teams with respective experts and coaches. Furthermore, there are multi-location hackathons, taking place at different venues at the same time. For example: *Futureland* – a company-internal hackathon ran by *Siemens* in 2018.[3]

Hackathons traditionally take place physically at certain locations; their setup is similar to the one of a LAN-party: there are chairs and tables grouped in a space big enough to accommodate all the teams, sometimes there are even individual rooms for each team. Normally, every participant brings their own computer to the event. This requires technical infrastructure such as network cables and power strips. Furthermore, a big assembly location is a necessary requirement, allowing for common sessions like opening, closing, workshops, and the side program. Usually, food, coffee, and soft drinks are provided by the host. Sometimes, hackathons are being hosted at a 'hackerspace'. Especially if extensive hardware work is to be carried out. "A hackerspace (also referred to as a 'hacklab', 'makerspace' or 'hackspace') is a community-operated workspace, which typically have the large and expensive pieces of equipment required for hardware prototyping (cf. Briscoe, 2014, pp. 3–4)." This includes 3D printers and tools for mechanical and electrical tinkering.

Until recently, the in person get-together of the participants and facilitators was seen as a necessity to run a successful hackathon and hardly questioned (cf. Kohne & Wehmeier, 2019, p. 38). As the following work will show, this assumption turns out to be incorrect. Forced by the global Covid-19 pandemic, hackathon organisers were moving forward online. The online hackathon format is budding worldwide, providing new possibilities (but also posing new challenges) which shall be further investigated in chapter 3 and 4.

2.2 Adoption of the hackathon in other domains

Having their origin in software development and computer science, in the last couple of years, hackathons became more interdisciplinary, cross-functional, and even cross-hierarchical, turning away from the code-based solution finding and opening up to a wider spectrum of challenges and audience. The hackathon's inherent qualities like disruptive brainstorming, design thinking, and agile teamwork, pose promising benefits for organisations (cf. Taylor & Clarke, 2018, p. 1). Being a fertile breeding ground for ideas and

[3] *Siemens Futureland* summary video: https://youtu.be/xI67fB-12wI, date of access: 10.12.2020.

innovation, it is not surprising that hackathons "have been adopted in various domains to generate innovative solutions, foster learning, build and expand communities and to tackle civic and ecological issues (Nolte, Alvarez, et al., 2020, p. 50)." In modern hackathons, programmers, designers, communicators, prototypers, marketing specialists, scientists, law experts, educators, and many others, work side by side on a project, aggregating wide and eclectic input from different domains and perspectives. This incorporates the big potential of hackathons: they can produce thought-out, sustainable, as well as creative and innovative solutions – not specific to software development. The results are manifold: apart from software or hardware prototypes, they can range from art and cultural artifacts to less palpable outcomes such as business models, workflows, laws, research approaches, and other concepts. Many companies hold internal (employees only) and external (open for all or a wider audience) hackathons to test new or further develop existing products and learn more about their potential application, finding alternatives to existing products, giving employees the possibility to implement own ideas, or tackling company-specific pain points (cf. Kohne & Wehmeier, 2019, p. 17). Classic examples of hackathon-induced innovations are *Facebook*'s 'Like' button (cf. Briscoe, 2014, p. 6), which has been adopted by many social media platforms and online forums, or the popular dating app *Tinder* (cf. Kohne & Wehmeier, 2019, p. 8), which has drastically changed the way people meet and date in the digital age.

Naturally, not every single hackathon gives birth to seminal novelties, some hackathons yield no promising outcomes, or projects are not continued after the event. Hackathons are not only held to drive innovation, but they offer less outcome-driven benefits, too. Instead pursuing innovation, some hackathon events prioritise different aspects. For example, the corporate world has discovered hackathons as a means of recruitment. Many companies – especially in the US – organise hackathons as assessment centres, scouting for young, talented people with good problem-solving, team-playing, and leadership capabilities. The capabilities are being displayed by the participants in the course of such event (cf. Kohne & Wehmeier, 2019, p. 2). Furthermore, a hackathon can foster those and other capabilities (cf. Mtsweni & Abdullah, 2015, p. 91). During a hackathon, participants constantly teach and learn from each other. Many hackathons (mainly those hosted by universities and high schools) are less outcome-driven in regard to prototypes, concepts, etc., but prioritise the learning experience as well as the network and community-building opportunities (cf. Drouhard et al., 2017, p. 1). Another perk of organising a hackathon is its marketing value. Hackathons are in vogue among young professionals (especially in the tech industry) and

"they can attract diverse participants from different ethnic backgrounds, skills, education levels, and (research) experience (Nolte, Alvarez, et al., 2020, p. 55)." *Google*, *Facebook*, *Yahoo!* (cf. Trainer et al., 2016, p. 1117), as well as research organisations such as *NASA* or the *European Organization for Nuclear Research (CERN)* conduct hackathons regularly. Additionally, non-profit organisations might organise a hackathon – given they are an increasingly popular phenomenon – to raise awareness and advocacy as well as a means of public engagement (cf. Taylor & Clarke, 2018, pp. 4–5).

As one can see, the application and adaptation of the hackathon concept to various domains and purposes entail notable benefits, unlocking the hackathon's vast potential. Similar to the hackathon's development from being only meant for software development to becoming a useful instrument in many other fields as well, it seems self-evident that a disentanglement of the hackathon's physical boundaries can further increase its usefulness and application possibilities. Therefore, in chapter 4, it shall be investigated what benefits and challenges online hackathons can potentially bring to the table and whether they can add value to the hackathon landscape.

2.3 Working towards a hackathon typology

There are many different formats or 'sub-genres' which have emerged from the traditional hackathon, adapting its concept regarding purposes and goals. Some of those formats have their own names: *ideathons*, *mapathons*, *coding challenges*, *datathons*, *business-case competitions*, etc., each featuring own peculiarities. To give concrete examples of the hackathon concept and how it is applied in different ways, in the following, two recurring hackathons are briefly depicted: the *THE Port Humanitarian Hackathon* and the *CERN Webfest.* Even though the hackathon formats of the two examples are quite different, what they have in common is that, before 2020, they used to take place physically at facilities of *CERN* in Geneva over one weekend. Due to the outbreak of the Covid-19 pandemic, both 2020 editions of those hackathons were held online.[4]

- The first of the two examples, the *THE Port Humanitarian Hackathon*, is an annual hackathon organised by *THE Port Association*[5] since 2014. It aims to tackle challenges related to the humanitarian sector. The challenges are presented by humanitarian organisations such as the *United Nations*, *Terre des Hommes*, or the *International Committee of the Red Cross.* The *THE Port Association* acts as a

[4] It is worth mentioning that the author of this thesis was involved in the organisation of both events.
[5] *THE Port Association* website: http://theport.ch/, date of access: 12.12.2020.

facilitator and mediator; it provides the infrastructure for the hackathon, selects an interdisciplinary set of participants, and allocates them to their teams (and, therefore, challenges), based on their skill set and background. The *THE Port Humanitarian Hackathon* editions have yielded valuable contributions to the humanitarian sector, such as a reliable cooling system for vaccine transport to remote areas or improved body bags, which increase the time for corpse identification (Potamianos, 2020). Prizes are not awarded during this hackathon. Instead, its main objective is to create a lasting impact for a range of good causes.

- The *CERN Webfest*[6] also takes place annually since 2012 and is based on open web technologies. The participants, mainly attendees of the *CERN Summer Student Programme*[7] (however, the hackathon is open to everyone and there is no registration limit), work in self-allocated teams to design web applications that encourage the public to learn more about science and research carried out at *CERN*. The best projects are awarded by a jury with small prizes. The participants are encouraged to work on their own ideas, additionally, some challenges are being curated by the organisers and can be picked up. For this hackathon, the learning, networking, and fun aspects of the hackathon stand in the foreground. Nevertheless, the *CERN Webfest* produces innovative applications, like the educational game *ParticleQuest*.

As demonstrated by the examples above, there are different adaptations of the basic hackathon concept, yet they have their own peculiarities and thus vary in purpose, audience, mode of facilitation, duration, toolkit, rules, team setup, accessibility, and numerous other modalities. The different purposes for holding a hackathon with its resulting versatile formats, as well as the occurrence of vague terminology, call for a thorough and uniform hackathon typology which has not been put on paper yet.[8] There has been some pioneering work to classify hackathons, for example, Drouhard et al. drafted a "preliminary typology" based on their own fieldwork, hoping that such typology might "facilitate the development and articulation of new lines of inquiry, research questions, and theory (Drouhard et al., 2017, p. 2)." The typology presented in their paper takes a hackathon's purpose as the main characteristic of distinction. In an online article, Luenendonk takes a similar approach, yet his typology deviates notably from the one presented by Drouhard et al. (cf. Luenendonk,

[6] *CERN Webfest website*: https://webfest.cern/, date of access: 14.12.2020.
[7] *CERN Summer Student Programme* website: https://home.cern/summer-student-programme, date of access: 14.12.2020.
[8] This refers to December 2020 and to the best of the author's knowledge.

2019). As indicated, next to the purpose of a hackathon, there are other aspects to the event type that qualify (some more, some less) to be taken as the basic characteristic for distinction in order to create a typology: facilitation mode, target audience, the toolkit that is being used for hacking, the duration, the accessibility, the nature of the challenges, or – catered to in this work – the 'venue'. Furthermore, the hackathon phenomenon undergoes a fast-paced evolution with numerous sprouting branches in its lineage, enabled by the constant enhancement of technological possibilities and the event's growing fields of application. All the above complexity renders the development of a complete hackathon typology quite challenging. This thesis does not aim to create a complete hackathon typology. However, its empirical description of the online hackathon as a relatively new element on the hackathon landscape will hopefully provide useful groundwork for a more elaborate typology of hackathons and their different formats in the future.

3. Typology of the online hackathon

As already alluded to in chapter 1.2, scientifically investigating this very recent mode of hackathon facilitation without much data at hand is challenging since prior research is scarce. As a result, the chapters 3 and 4 are an aggregation of the author's own account on the topic, the accounts of the author's co-organisers of past online hackathons, and resources provided by organisations which hosted online hackathons according to this new model. In this chapter, some inferences are made, and some hypotheses are stated, which have not been proven by a formal gathering and analysis of data but merely by observation and analysis of past events. The aim is to collect initial thoughts and ideas, hopefully being helpful for future investigations into this young phenomenon. For the evaluation of said inferences and hypotheses, findings on online collaboration in general and online learning environments are put into context, given online hackathons harbour characteristics of both domains.

3.1 Disambiguation

To begin with, disambiguation seems adequate: the term *online hackathon* is, like many terms in the hackathon terminology, vague and – as for the physical hackathon – there exist different types of events to which many people just refer to as 'online hackathons'. The pre-pandemic online hackathons that occurred were mostly a different format than the ones that are subject to this thesis. This pre-pandemic type of 'online hackathons' takes place over multiple weeks and months (cf. Kohne & Wehmeier, 2019, p. 23) and is almost entirely

focused on coding.[9] Hence, this kind of event should rather be referred to as 'coding challenge' or something similar. For this event, organisations (mainly companies) present the challenges online, giving participants a relatively long period of time to hack the challenge as a side project, not necessarily in teams. Gatherings rarely happen. This means the participants were more or less left alone to hack their challenges over a couple of weeks, rendering the hackathon rather anonymous with core elements like networking, strengthening of social ties and community-building (cf. Drouhard et al., 2017, p. 1) being neglected. The event-type described in the following, to which the author refers to as 'online hackathon', is in its nature much closer to the 'classic' hackathon concept described in chapter 2.1. Like the physical hackathon, this online hackathon is a multi-day, ongoing event of about 48 hours where people (virtually) come together to hack, learn, network, and socialise. In plain terms, one could say, the online hackathon constitutes the same procedures and logic as a physical hackathon, 'just' taking place virtually. This statement is, of course, oversimplified as the following pages will show, but the described format is very close to the 'classic' hackathon concept without extensive modifications.

3.2 Origin and upturn of the online hackathon

The physical hackathon made its enforced leap into the virtual world in March 2020, induced by the first Covid-19 wave. Before the coronavirus pandemic and the resulting proliferation of virtual collaboration, the short-term mode of about 48 hours duration, that is common for a physical hackathon, was not seen fit to be transferred to an online environment (cf. Kohne & Wehmeier, 2019, p. 38). Online hackathons in said format were rare and rather experimental. This has changed thanks to the coronavirus crisis. Shocked by the relatively sudden outbreak of the pandemic, Governments, NGOs, companies, and academic institutions worldwide were frantically looking for counter measures to mitigate the first wave's impact. One of the said measures was the organisation of hackathons. Two Estonian organisations, *Garage48* and *Accelerate Estonia*, were first to organise a hackathon event together online on 13 to 15 March 2020 as a response to the crisis. The idea was to harness crowd intelligence via a 48-hour online hackathon to tackle the myriad of challenges society was faced with. Over 1000 people took part in the event dubbed *Hack the Crisis*[10] (cf. Bauer & Pääru, 2020). One week later, under the patronage of the German Government, a collective

[9] Some examples for this type of event that took place in previous years are the *#KyberDeFi Virtual Hackathon* (https://blog.kyber.network/kyberdefi-virtual-hackathon-76ad120a3971), the *Beginner Hack 1.0* (https://www.hackerearth.com/de/challenges/hackathon/beginner-hack-10/), or the *Hack for Education* (https://www.hackerearth.com/de/challenges/hackathon/hack-for-education/), dates of access: 15.12.2020.
[10] *Hack the Crisis* summary: https://accelerateestonia.ee/en/hack-the-crisis/, date of access: 14.12.2020.

of several NGOs, coming from the digital and innovation sector, organised the *#WirVsVirus*[11] hackathon, hosting over 28 000 participants and turning the event into the world's largest hackathon thus far (cf. The Innovation in Politics Institute, 2020). Despite having had technical difficulties in virtually accommodating such a large number of hackers (cf. Neuman, 2020), the hackathon has yielded 1500 solutions and is seen as a success, receiving personal praise from Chancellor Angela Merkel (cf. Bundesregierung, 2020). In a video statement, Merkel acknowledges the (online) hackathon concept as a useful instrument for crisis management, that is the channelling of different perspectives into ideas to find practical and acceptable solutions for societal problems – "creative, innovative, and digital (Merkel, 2020)." Without its explicit mentioning, one can draw the conclusion that Merkel refers to the online hackathon concept in her statement when praising the hackathon's value in a crisis[12] (under the pretence that she is probably not consciously aware of any distinctions regarding the hackathon phenomenon). The fact that the (online) hackathon phenomenon receives acknowledgement by decision-makers of highest ranks, and, furthermore, them being aware of the hackathon's potential and applicability, is remarkable. The media covered the various online hackathons that have been held to tackle the crisis' first impact, raising awareness among society towards the (online) hackathon in regard to its purpose and benefits. This is another good reason why the (online) hackathon phenomenon needs to be explored and understood better. During the first wave of the coronavirus spread, many other governments and organisations conducted online hackathons to come up with solutions to tackle the crisis, for example, *HackYeah*[13] in Poland, *#VersusVirus*[14] in Switzerland, *Hack A Cause*[15] in India, or the *CERN Webfest 2020* organised by *CERN*. As for the projects developed during these hackathons, many of them were carried further after the hackathon, evolving into mature states. For example, *Pandemia Parliament*[16], an online tool that aims to enable virtual balloting for parliaments, emerged from the Swiss #VersusVirus hackathon, is running an unofficial trail on a municipal level (cf. Graf, 2020). However, many others of

[11] *WirVsVirus* website: https://wirvsvirus.org/ date of access: 17.12.2020.
[12] The semantics in this context are important, stressing the benefits of the online hackathon which will be elaborated later in this document. Given the contextual situation, a physical hackathon to that extend could have never been set up in such a short amount of time (if ever). Also, physical contact had to be avoided at the time the event was held. Hence, when Merkel uses the word 'hackathon', it seems obvious that she actually refers to the virtual hackathon form – the online hackathon.
[13] *HackYeah* website: https://hackyeah.pl/winners-online-april/, date of access: 17.12.2020.
[14] *#VersusVirus* website: https://www.versusvirus.ch/, date of access: 17.12.2020.
[15] *Hack-A-Cause* website: http://www.hackacause.in/, date of access: 17.12.2020.
[16] *Pandemia Parliament* website: https://www.pandemia-parliament.ch/, date of access: 17.12.2020.

those projects stalled due to lack of quality, guidance, and/or the lack of time of the participants to pursue them any further after the lockdown had been lifted.

Despite the omnipresent pandemic, in 2020, online hackathons were conducted in all kinds of fields, not only those related to the coronavirus crisis. Due to travel bans, contact restrictions, or, more generally, the attempt to slow down the dissemination of the virus, hackathon organisers had to move forward online, even after the first wave had abated. Commercial hackathon organisers and non-profit organisations alike have started to explore this budding event type. One of the biggest commercial hackathon companies, *Devpost*[17], listed dozens of online hackathons in the 48h-format by the end of 2020. The NGO *THE Port Association*, from the above-mentioned example in chapter 2.3, facilitated their annual humanitarian hackathon in 2020 online. The same applies to the *SciCommHack*[18], organised by the *Synaptics Association*, the *CERN Webfest*, or the *Random Power Hackathon*[19], funded by the *ATTRACT Project*[20], to name a few. Most likely, many hackathon 'franchises', who had to conduct an exceptional online hackathon in 2020, will move their sequential events back into a physical environment as soon as the coronavirus situation allows it. Yet it is likely that some of them will not do so, having realised that the online hackathon concept (or perhaps a hybrid of the on-site and online event) fits their needs better. Furthermore, commercial hackathon organisers have added the online hackathon and respective facilitation tools to their portfolio[21], surely not just as a temporary product. It can be assumed, that the online hackathon – after being deemed as unnecessary, ineffective, or too elaborate for a long time (cf. Kohne & Wehmeier, 2019, p. 38) – finally has gained some foothold in the hackathon community. For some organisations, only online hackathons come into question since there are use cases to which its physical counterpart is not applicable, but an online event seems adequate. This will be investigated more thoroughly in chapter 5. But before, the online hackathon needs to be described regarding its peculiarities (logic, protocol) and infrastructural requirements. This description is subject to the following.

[17] *Devpost* website: https://devpost.com/, date of access: 16.12.2020.
[18] *SciCommHack* website: https://www.scicommhack.com/, date of access: 20.12.2020.
[19] *Random Power Hackathon* website: https://www.randompower.eu/randompower-hackaton/, date of access: 20.12.2020.
[20] ATTRACT website: https://attract-eu.com/, date of access: 20.12.2020.
[21] Examples are *Devpost* (https://devpost.com/), *Hackerearth* (https://www.hackerearth.com/), or *mettl* (https://mettl.com/en/online-hackathons/).

3.3 Peculiarities of the online hackathon

Generally speaking, the online hackathon follows in most respects the example of the physical hackathon; as reconstructed in the previous chapter, it has originated through the conversion of the physical hackathon into the digital environment. Hence, taking the definition drafted in chapter 2.1 as a baseline and adapting it to the online hackathon, its definition could go as follows:

> *An online hackathon is a problem-focused event, where people virtually come together in a predefined time frame (mostly 48 hours), collaborating online, working in small teams on novel ideas or technologies as well as challenges, creating something new and innovative.*

However, the online hackathon is not a mere emulation of the physical hackathon stripped of its physical aspects. The online hackathon has its own dynamics, opening new ways to exhaust the hackathon concept. But before the online hackathon's chances – as well as its challenges – are further expounded and evaluated (see chapter 4), its characteristics, that distinguish it from its physical pendant, shall be investigated without too much of extensive assessment, plainly elaborating the distinction of the online hackathon.

To begin with, stating the obvious, the online hackathon is a purely virtual event. As good as all interaction within the framework of an online hackathon takes place virtually.[22] There is no physical venue where everyone comes together, hence no physical proximity either.[23] Participants are often wide distances apart, at some events even scattered about multiple time zones across the globe. Concurrently, online hackathons comprise both synchronous and asynchronous communication, whereas physical hackathons feature mostly the former, except during 'preparation phases'. The online hackathon can host larger numbers of participants than its physical relative. This implies that the online hackathon is more accessible; people do not need to travel to a certain place to take part. Which leads to the next major distinction: the economic aspects. The monetary and time expenses of hosting an online event are lower compared to an on-site event.

[22] Although social interactions take place virtually only, some hardware work might still be carried out. For example, one team member – having access to the necessary tools or facilities – conducts some prototyping in a workshop or draws design sketches at their desk.

[23] There are cases, where, as far as the circumstances allow it, teams (or few team members) meet up in person to take part in an online hackathon together, staying together locally for the event's duration. However, this is an edge case.

Whereas the physical hackathon is an intensely digitalised event already, utilising a wide spectrum of CSCW (Computer Supported Collaborative Work) tools (cf. Nolte, Alvarez, et al., 2020, p. 61), the online facilitation of a hackathon is, due to its intrinsic nature, completely dependent on software and hardware solutions. Hence, there are technical prerequisites on both sides: participants and facilitators (more on the technical facilitation in chapter 3.4). Online collaboration has been in constant evolution (cf. Hammond, 2017, p. 1019), becoming more and more institutionalised, efficient, developed, and prevalent, as well as gaining more importance. The recent coronavirus pandemic has boosted this development in an unprecedented manner and the online hackathon is one of the many beneficiaries of that change of collaboration paradigms. The CSCW tools (e.g., *Slack* or *Zoom*) are continually improving in functionality; increasingly, people get familiar with them in their home-offices, and, frequently, new CSCW innovations emerge. At the same time, this implies that the online hackathon concept will undergo further evolution in parallel to online collaboration, given the former is a specialised instance of the latter.

The online hackathon's agenda can be the same as for the physical hackathon. Past events like *#VersusVirus*, the *CERN Webfest*, or the *THE Port Humanitarian Hackathon*, have proven that online facilitation does not need to cause any omissions regarding the agenda, that is, the various sub-events during the hackathon. This includes workshops, keynotes, side programme, etc. Actually, any omission of 'standard programme' is being avoided and adding sessions to compensate for the impaired social presence is being deemed adequate. In other words, an online hackathon has the same agenda items as a physical hackathon or even more of them. Pre-hack phase, opening session, closing session, workshops, update sessions, and socialising events in between, are common programme points.[24] This needs to be stressed because, at first glance, it might seem appropriate to leave out programme elements that are non-essential for the hackathon's facilitation such as networking and socialising events, arguing that online gatherings are not as fun, effective, or meaningful as physical ones and, therefore, obsolete or neglectable.[25] However, this is a fallacy: firstly, many participant's motivation to take part in a hackathon lies in the opportunity to socialise with people, to enhance their network, and to be part of a community. The participant's expectations regarding these essential attractors can be met with the side programme and

[24] What is considered to be the 'standard programme' for a hackathon is a matter of interpretation and certainly debatable. Some experts would probably only count opening and closing as 'standard' and workshops, pre-hack phase, and socialising programmes as options.
[25] Put in a wider context, this caveat is the reason why online hackathons were having a hard time thus far after all.

update sessions. Secondly, apart from the motivational aspect, virtual gatherings are essential for an online hackathon's success in creating a harmonious social environment, increasing effectiveness in collaboration, even though it is indisputable that online gatherings cannot furnish the same, advantageous social environment as physical ones (more on that in chapter 4). The abovementioned update sessions are usually less frequent at physical events. They are an optional (virtual) get-together, in which a moderator or facilitator gives updates on the hackathon's progress, making announcements and answering frequently asked questions. In addition, participants, mentors, or organisers can be interviewed to share their impressions of the hackathon. All in all, the updates aim to increase the frequency of times hackathon attendees interact and, thus, convey a sense of togetherness and community.

Beforehand	Friday 03.04.	Saturday 04.04.	Sunday 05.04.	Monday 06.04.
02.04.2020 Registration deadline for participants and mentors Stay healthy and at home!	**09:00-11:00** Tech Access & Onboarding of participants **11:00–13:30** Team building session & virtual networking **14:00** Deadline: All teams ready & online **14:00-14:30** Kick Off Event **15:00-15:30** *How to* get started - tech intro **From 17.00** Mentors available on Slack channels **17:00-17:30** *How to* boost your creativity **18.15** Big Surprise **19:00** Deadline for choosing your challenge **19:00-19:30** Inspirational Panel **20:00-20:30** *How to* frame a problem **#funversusvirus** **20:00-21:00** Live streamed concert by Disco Pizco **21:00-24:00** Online-Disco with Rosanna Grüter and Purple Drain	**08:00–08:40** Wake Up Yoga **08:45-10:00** Müesli concerts with Artemi and Seth G **All day long** Mentors available & support via Slack **10:00** VersusVirus Update #1 **10:30-11:00** Inspirational Panel **11:00-11:30** *How to* create a concept **12:00-13:00** Networking - Zoom-Chatroulette **13:00-13:30** *How to* create a prototype **13:45** Inspirational Surprise **14:00-14:30** Energizer with Pat Burgener **15:00-15:30** *How to* pitch your idea **16:00-16:30** Inspirational Panel **17:00-17:30** *How to* visualise your idea **18:00-18:30** *How to* create a simple video **19:45** VersusVirus Update #2	**08:00–08:40** Wake-up Yoga **08:45-10:00** Müesli concerts with Chasing Tales and Musketeer **All day long** Mentors available & support via Slack **10:00** VersusVirus Update #3 **10:45-11:15** kidsversusvirus **12:00-12:30** *How to* upload your solutions on the app **13:30-14:00** kidsversusvirus **14.00-14.45** The Human Jukebox - afternoon concert for families **18:00** Submission deadline **18:00–18:30** End of Hack Event **#funversusvirus** **18.30-19.30** Live concert MoreEats **18:30-22:00** Zoom-Dancefloor	**19:00-20:30** Closing ceremony and announcement of highlights

Figure 1 : ***Timetable of the Swiss #VersusVirus Online Hackathon in April 2020****, showing the variety of programme an online hackathon can offer. The actual hacking took place in between these sessions. The sub-events are listed in different colours: in red, all the main events, announcements, and deadlines; in blue, the workshops; and in green, all the fun and socialising events.*

Sharing the agenda with the physical hackathon, online hackathons also have a similar duration. The online hackathon (preparation phase not included) is usually set for about 48 hours, preferably on a weekend (in the Western world), keeping the event in a sensible range of time. Long term hackathon events can suffer a loss of impetus if they drag on for too long

(cf. Kohne & Wehmeier, 2019, p. 23). However, some hackathon formats are characterised by long-term facilitation like the aforementioned ‘coding challenges’. Another aspect to mention is the time zones a virtual hackathon can stretch across. Potentially, an online hackathon can be a global event like, for example, the *CERN Webfest 2020*. Usually, the host’s time zone is the prevalent one.

3.4 Technical facilitation of an online hackathon

It goes without saying that online hackathons need a website, where all the necessary information concerning the event is given. A mailbox is recommended, with which the organisers can communicate before, during, and after the event with all stakeholders. Also, social media channels are helpful and should be exploited. Since the utilization of a website, mailbox, and social media channels is pretty much analogous to physical hackathons, there will be no further elaboration of these aspects, given they have been covered in past works and do not differ regarding the virtual hackathon. In the following, the emphasis is on the technical aspects needed for the facilitation of an online hackathon.

The technical prerequisites for an online hackathon are software – mainly CSCW tools – and hardware that enable virtual collaboration, as well as specific software and hardware that organisers use as technical infrastructure for facilitation. For participants, the most basic hardware required is a computer with an internet connection, enabling online collaboration (cf. Hammond, 2017, p. 1012). A microphone and a camera should be available for easier communication with fellow hackers and attending the diverse sessions. CSCW tools are essential for online collaboration. They enable communication between participants (and organisers) as well as an exchange of data and code (cf. Kohne & Wehmeier, 2019, p. 40). The CSCW tools used for virtual gatherings, i.e., synchronous communication, are videoconferencing applications such as *Zoom* or *Microsoft Teams*. They offer videoconferencing for a high number of participants which is important to facilitate all official agenda items, such as opening, closing, workshops, or the fun programme. In case the number of participants exceeds the videoconferencing platform’s capabilities (as it was the case for *#WirVsVirus*), setting up a live webcast for the hackathon’s sub-events is a solution. For this, a videoconference constitutes the ‘stage’, only attended by people who are contributing to the content of the webcast session such as moderators, keynote speakers, panellists, music acts, etc. This videoconference is streamed live to the hackathon’s webpage, *Youtube*, or social media channels. Webcasting can make the event accessible for the wider public and provide the hackathon with more visibility. Ideally, participants can

also access videoconferencing tools to work with their teams aside from the main programme, i.e., during the hacking sessions. This is of advantage: "As social presence theory predicts, synchronous video technologies offer a higher degree of possibilities to convey socio-emotional cues and establish or maintain interpersonal connections (Nolte, Alvarez, et al., 2020, p. 139)."

Other CSCW tools that are pivotal to a hackathon are platforms like *Slack* and *Mattermost*. This applies to online and physical hackathons alike. However, for the former, those tools become even more important, allowing synchronous and asynchronous communication among the teams as well as the organisers. Next to being the basic platform for collaboration among the teams, those tools are also used for propagating announcements (links, reminders, updates) or entertaining a help desk. The extensive usage of technology and the spatial displacement of participants make a help desk an indispensable element for an online hackathon. Furthermore, those kinds of platforms offer (simple) file and data exchange. To enhance and improve file sharing and collaborative work, there are usually additional solutions like cloud-based applications such as *Google Drive* or *GitHub*, which are widely used in any hackathon format. Moreover, tools like virtual blackboards, pinboards, sketch boards, list-making apps, etc. are used to simplify and improve collaboration. Such tools can actually benefit further work on the project after the hackathon has ended: during an on-site event, analogous data collected on blackboards etc. does not need to be digitalised first (cf. Trainer et al., 2016, p. 1126). For some hackathons, instead of presenting their project outcomes live during the closing, participants had to send in a video presentation. In that case, video editing tools are needed.

Complementing the CSCW tools, the organisers of an online hackathon can use applications that support the structural facilitation of the hackathon. For the *#VersusVirus* hackathons, for example, the organisation team developed a web application that helped to allocate the participants to their teams at the beginning of the event. An algorithm put the teams together based on the participants' backgrounds and priorities which they had entered in a short questionnaire in advance. Furthermore, the app was used to collect the project deliverables from the teams at the end of the hackathon and gave an overview of the event's schedule. Further functions of such hackathon applications can include the facilitation of the judging process or a help desk. *BeMyApp*[26] is a commercial solution that offers such functions for (online) hackathon facilitation.

[26] *BeMyApp* website: http://www.bemyapp.com/, date of access: 25.12.2020.

Web applications such as *Remotely Green*[27], *Veertly*[28], or *hopin*[29], (the former two originated in hackathons) are further, optional tools that can be used to support a hackathon's online facilitation. With platforms like *Remotely Green*, the organisers can emulate random social encounters one would have during an on-site event like a catch-up by the water-cooler. The aim is fostering networking and community building by transferring these occurrences into the online environment. *Veertly* and *hopin* are online event platforms that offer many functions, simulating an event venue with virtual stages, break out rooms, and other possibilities to meet up online.

4 Assessment of the online hackathon's potential

Even though the general hackathon concept (see chapter 2.1) remains the same at its core when exercised in an online environment, it is evident, that such digitalisation entails ramifications not only on the hackathon's characteristics and facilitation, but it also bears resulting benefits and drawbacks of its own. A fully technology-dependent online event poses multiple chances as well as challenges regarding the application of the hackathon concept. Although the aforementioned benefits of the general hackathon concept (innovation, learning, networking, etc.) remain in an online environment, their emphasis changes – some for the better, some for the worse. On top of that, an online hackathon creates new chances and challenges thus far unknown to the general hackathon concept.

4.1. Chances and benefits

As mentioned already, the online hackathon is a powerful instrument, offering great potential to society. They excel in terms of costs, accessibility, flexibility, scalability, participation, new learnings, intercultural exchange, and even eco-friendliness compared to their physical pendant.

Costs

Some costs accrue only for an on-site event and not for a virtual one and vice versa. Also, some costs apply for both events alike, such as software licenses, the salary of organising personnel, remuneration for keynote speakers, workshop facilitators, or music acts (side programme), (digital) giveaways, advertisement (if applicable), prizes, etc. However, considering the bottom line, the online hackathon is in general more economical than on-site

[27] *Remotely Green* website: https://remotely.green/, date of access: 25.12.2020.
[28] *Veertly* website: https://www.veertly.com/, date of access: 25.12.2020.
[29] *hopin* website: https://hopin.com/, date of access: 25.12.2020.

events, evidently, because there is no physical location needed. Organisers do not need to book a venue to hold their event since rental costs are being saved. Also, cleaning costs or any other venue-related expenditures do not apply. Furthermore, there is no budgeting on catering, travelling and accommodation. Depending on the hackathon, such costs are covered either by the organisers or the participants. And, of course, this does not only save monetary expenses: time is being saved as well – there is no need to prepare or clean the venue and no time spent on travelling. Some expenses only apply to an online event and not to an on-site event such as specific software licenses or technical infrastructure, but, realistically, these costs are still nowhere near the costs of a physical event. In total, the costs per participant of an online hackathon are usually lower. The low-budget character of the online hackathon goes well with the general grassroots spirit adherent to the hackathon phenomenon. Usually, hackathons are not high-cost events (yet some of them are), enabling 'innovation under austerity'(cf. Briscoe, 2014, p. 2), which is one explanation for their popularity in countries like Brazil or India (cf. Swati Shinde, 2020). One can assume that the possibility to host an economically-savvy hackathon online could carry this trend even further; the online hackathon poses an attractive instrument to non-profit organisations as well as public institutions with low funding like clubs, associations, social movements, and tech communities.

Accessibility

Without a physical venue, the online hackathon – as any online event – offers a high degree of accessibility. To take part, everything a participant needs is a laptop with an internet connection (see chapter 3.4). The journey to the hackathon venue is obsolete, travel impediments like high costs, time constraints, visa requirements, or health issues, which potentially keep interested hackathon participants from attending, are irrelevant. Arguably, this factor could enhance the spectrum of participants. People who cannot afford travel and accommodation costs are not excluded from online hackathons. There is no time to spend on travelling to a hackathon which can influence a potential participant's decision whether to take part or not, given they might have to take leave at work. Also, people, coming from countries where it is not easy to travel from (Iran, Pakistan, etc.), can join the online hackathon more easily. Besides, it could be imagined that elderly people, who want to attend a hackathon but might feel 'out of place' in a physical hackathon environment, are more likely to attend an online hackathon. The same applies to people who suffer social anxiety and find more comfort in interacting with others online (cf. Prizant-Passal et al., 2016, p. 227). Taking all of this into account, it can be assumed that the online hackathon, thanks

to its accessibility, can foster diversity in hackathon events, resulting in diverse input and higher effectiveness in harvesting crowd intelligence.

Flexibility

An online hackathon offers flexibility for organisers and participants alike. Online hackathons can be organised in a relatively short amount of time, as the pandemic-induced online hackathons prove. The decision to hold the hackathon does not necessarily need to be made months in advance, as it is usual for on-site hackathons. This makes the online hackathon more applicable to find targeted solutions to recent and pressing challenges. Also, organisations can use the hackathon as an innovation instrument more dynamically. Participants do not need to commit to the event months and weeks in advance, sorting travel and accommodation, blocking days in their schedule. They are less likely to face the uncertainty of committing to an event a long time ahead, not knowing whether they will be able to attend, which eventually prevents them from attending in the first place. For online events, registration can be open until a few days prior to the event's start. The extensive flexibility of online events is also beneficial for any other stakeholder apart from participants, such as workshop facilitators, judges, or non-participating spectators. Saving travel time and costs also enhances the chances of availability regarding the stakeholders, someone is more likely available to give a workshop or keynote online than on-site.

Scalability

The pandemic-related online hackathons from March and April 2020 show that thousands of participants can be hosted during such events. With its 28 000 attendees, the *#WirVsVirus* hackathon ran into problems regarding the technical infrastructure (cf. Neuman, 2020). Nevertheless, this was rather due to unexpected high participant numbers the organisers were not really prepared for than to limitations of technology in general. The online hackathon offers immense scalability. Being able to organise events this size opens new ways in driving innovation through crowd intelligence, given the event's concept is thought-out and adapted to high attendance. As for any hackathon, the outcome, that is the submitted solutions by the hacking teams, varies in quality quite drastically. Yet, statistically, a big hackathon event with hundreds of submissions is likely to yield seminal innovations, given the hackathon environment is fit to nurture the projects adequately during their initial phase. Thus, holding a big-scale hackathon event can increase the chances of good outcomes – quality through quantity. Yet it goes without saying, that a high-scale approach has negative sides, such as high costs, drop-out rates, less social interactivity due to anonymity, etc. Not every single

online hackathon is automatically bound to become a high-scale event; its aim and purpose as well as the organisers' resources determine its size. However, having the option to scale up massively is a significant benefit that online hackathons offer and is also related to its benefit of accessibility, breaking attendee limits imposed by physical locations.

Participation and e-democratisation

Thanks to its accessibility and scalability, the online hackathon allows large-scale participation. As illustrated by the Covid-19-related hackathons, the online hackathon format enables the inclusion of citizens in finding solutions to challenges affecting society as a whole. Not only can governments harvest the collective intelligence of its citizens, but also the citizens themselves benefit from empowerment. Everyone can contribute – the fight against the crisis becomes, even more, a common effort. This hints to the vast possibilities and great potential the online hackathon could unlock in terms of e-democracy, from communal to national and even international levels. A proper investigation into the online hackathon concept applied to e-democracy would breach the scope of this work, however, it is certainly worth being carried out. Furthermore, the field of science can make use of the online hackathon's participative possibilities. In citizen science, where keen citizens are invited to participate in research on a voluntary basis, the online hackathon could benefit scientists and citizen scientists in many ways. This way of application is reflected on in chapter 5.

Further chances and benefits

Solely online collaboration is new to most people; many got diverted into this style of work during the coronavirus pandemic. Possibly, online hackathons foster new learnings in online collaboration. Participants need to work together in an online-only environment, using CSCW applications in order to succeed. Hence, participants who take part in an online hackathon hone their skills in this regard. This also benefits the follow-up work on the projects after the hackathon has ended: given team members are geographically separated again after the hackathon has ended, they must switch to online collaboration anyway in order to drive their project further. Already being used to this type of work as a team is certainly advantageous regarding the further pursuit of the project, however, this hypothesis requires further investigation. Additionally, the online hackathon opens new possibilities for intercultural exchange and collaboration, not being bound to a certain location. And, finally, online hackathons are eco-friendly because there is no travelling involved by any of the participants, organisers, or facilitators.

As described in this chapter, there are many positive aspects to an online hackathon which can – and should – be exploited to drive innovation, effectively creating sustainable and impactful solutions. How this could look like is subject to chapter 5, where possible applications in the field of citizen science are presented. Next, in order to complete the assessment of the online hackathon's potential, its challenges and drawbacks shall be investigated.

4.2 Challenges and drawbacks

The biggest challenge to surmount is the physical distance attendees are experiencing during an online event, heavily influencing the social aspects of the online hackathon. The lack of experience in online collaboration deserves consideration, too. Also, even though listed before as a benefit, a hackathon's accessibility can as well suffer from online execution. Lastly, online events seem to invoke less commitment and dedication among participants.

Physical distance regarding social interaction and collaboration

The probably gravest disadvantage of the online hackathon is the lack of physical presence compared to on-site social interaction. Social interaction and collaboration are always inhibited to some degree online. It is harder to convey emotions, feelings, moods to others. Gestures and body language are less effective; participants are stripped of a whole repertoire of communication tools (cf. Steven R. Aragon, 2003, p. 59). This is disadvantageous for team play and, ultimately, for collaboration itself. A team around hackathon-research pioneer Erik H. Trainer concludes: "Development of trust and 'team cognition' are essential for effective teams, and are relatively difficult to develop in online settings, compared to face-to-face (Trainer et al., 2016, p. 1117)." Trainer's team sees the theoretical framework of 'radical collocation' as a crucial aspect to a hackathon's teamwork process, which is hard to emulate in an online environment: 'radical collocation' is a strategy where a development team is put together in continuous spatial proximity for the duration of a project. This physical arrangement resembles many (on-site) hackathons. The 'radical collocation' setup "allows team members to easily move between activities, point to visible artifacts, mark them to reflect agreed-upon changes, and observe other participants moment to moment to identify members puzzled or deep in thought" and overhear conversations, with these circumstances leading to "significant productivity gains (Trainer et al., 2016, p. 1117)." It enables participants to watch others work and learn from them, as well as to socialise with them (Trainer et al., 2016, p. 1125). It is challenging to emulate an ongoing, close-proximity environment virtually. Even if the team stays continuously connected in real-time via

videoconferencing platforms to communicate with and see each other, it is still not possible for them to walk around and 'look over someone's shoulder' which affects learning from and casually supporting each other.

Next to the inability to move among the team's place of work, it is not possible for participants to 'roam the venue', checking on other participants and teams or visiting places where people frequently meet ('water-cooler catch-up'). Such casual, random meetups are normal for a physical hackathon. The reduction of social interactivity impedes networking and community building and makes it harder to create a sense of togetherness – aspects which are very important to a hackathon, regarding participation motivation, atmosphere, and the continuation of the project as well as the hackathon itself as a series. To mitigate the impediments caused by the absence of a physical venue, hackathon organisers try to implement (remote) social events, adding further sub-events to the hackathon's schedule and provide virtual places to catch-up (see chapter 3.4). Nevertheless, these current counter measures cannot compensate for the absence of physical proximity and leave room for further improvements in that respect.

Novelty of online collaboration – lack of experience and negative side-effects

On one level, impediments in remote collaboration are caused due to its relative novelty. Interacting remotely is not natural to human beings from a historical-anthropological point of view. The last few decades' technological progress, especially in the field of digitalisation, make real-time (i.e., synchronous and coordinated) remote interaction possible. Whereas younger people are already more disposed to online interaction due to their daily exposure to said technologies (cf. Hammond, 2017, p. 1011), *Generation Y* and the generations before experienced the upcoming of real-time remote collaboration as a new means of (team-)work, which was recently boosted by the global coronavirus pandemic. Getting into this new way of virtual collaboration is a cumbersome process: new rules and protocols need to be learned, well-internalised ones need to be adapted.

In addition, online collaboration can lead to negative side-effects like the new phenomenon of 'Zoom fatigue', which is described as "tiredness, anxiety, or worry resulting from overusing virtual videoconferencing platforms (Wiederhold, 2020, p. 437)." The ongoing learning process and the side-effects entailed by the novelty of online collaboration, incorporate impediments unknown to on-site collaboration, presumably affecting the online collaboration's quality in a negative way.

Accessibility

Whereas an online event is widely accessible from a technical perspective, some potential hackathon participants might be intimidated by the effort of online collaboration. This might apply to people who are not familiar with CSCW software or working with a computer in general. Some people might be averse towards online collaboration, given it is a new way of work one must get used to first. While attending a physical hackathon could be within their comfort zone, attending an online hackathon is not (this being the opposite of the positive effect an online event can have towards people with social anxiety, as shown in chapter 4.1). Another challenge in terms of accessibility is the online event's potential spread across multiple time zones. If an online hackathon can be attended globally, some time zones are either significantly ahead or significantly behind the prevalent time zone of the event. If the event is hosted in, say, central Europe, participants from North America and East Asia are handicapped. This means some hackers need to adapt their circadian rhythm to the event to attend the get-togethers. Moreover, including multiple time zones can cause further problems regarding collaboration among the teams; to mitigate time-related issues, it is best to form teams with participants from similar time zones. The prevalent time zone is usually the one of the hosts. However, adapting the prevalent time zone to the comfort of the majority, that is, the one where most participants live in, seems also adequate.

Another impediment regarding accessibility is the general access to the internet. In some regions (especially in the third world), due to austerity, governmental restrictions, or the lack of infrastructure, people do not have a stable internet connection and suitable devices (if any at all) and cannot partake in an online hackathon.

Participant commitment and dedication

It can be assumed that participants attending an online hackathon are not developing the same extent of commitment and dedication as for a physical hackathon, given its increased anonymity, fewer social interactions, and its reduced investment in taking part. For taking part in a physical hackathon, participants must invest time and money to get to the venue and organise accommodation. After already putting effort into pre-hack participation, sorting out travel and accommodation, and spending time on travel, a participant rarely opts out of a physical hackathon. When they are at the venue with their peers, they are most likely to dedicate fully to the project. For online events, there is little or no prior investment. Participants might sign up to the event to keep their options open, yet when the time comes,

they do not show up. Also, if they are not happy with their challenge or team, they might just drop out during the event, fearing little consequences.

5. Application of the online hackathon in citizen science

Drafting use cases for the many different fields and purposes that the online hackathon could be applied to would exceed the scope of this thesis and is an investigation of its own. However, to give a better notion of how such uses cases in a specific field could look, an example is explicated in this last part of the thesis. Owing to the author's background in science communication and the hackathon concept's affinity to citizen science, citizen science will serve as an instance of a potential online hackathon application.

5.1 Similarities of the hackathon concept and citizen science

Citizen science embodies one of the most dramatic developments in the field of science communication (cf. Lewenstein, 2016, p. 1). Notably, both phenomena – citizen science and the hackathon – share the fast-paced evolution and expanse of their domains in the past two decades, probably correlated to growing virtual interconnectivity and the resulting cambric explosion of CSCW tools and practices. But this is not the only shared trait of citizen science and hackathons: as for the majority of hackathons, citizen-science projects survive on voluntary participation; mostly a heterogenous bunch of people who commit to working together on a mutual (scientific) project for a certain amount of time, guided and supported by experts (cf. Bonn et al., 2018, p. 3). Moreover, "citizen science can expand stakeholder participation and introduce new perspectives and information as well as new partnerships (Bonn et al., 2018, p. 2)." Also, citizen-science projects foster learning among participants, enabling them to enhance their skill set and their scientific understanding (cf. Bonney et al., 2009, p. 983). Taking all this into account, arguably, hackathons – at least some of them, depending on their framework and purpose – can be contemplated as small, partial citizen-science projects. Furthermore, with minor reservations, the hackathon concept is perfectly reconcilable with the *Ten principles of citizen science* by the *European Citizen Science Organisation* (European Citizen Science Association, 2020). Assessing the abovementioned similarities, it is evident, that citizen science can benefit from hackathon events. Unsurprisingly, (physical) hackathons focused on citizen science are already being held (cf. Roche & Davis, 2017, p. 2), for example, the Geneva-based *Citizen Cyberlab*[30] is a

[30] *Citizen Cyberlab* website: https://www.citizencyberlab.org/, date of access: 28.12.2020.

pioneering institution in the field, frequently organising on-site hackathons for citizen-science purposes.

Consequently, there is a large potential for citizen science to exploit the hackathon's recent online format as well. It can help in meeting the demands that are coming from within the citizen-science community, pleading for more use of new methods and technologies (cf. Bonn et al., 2018, p. 68). Thus far, it appears that the only official online hackathon in the 48h-format related to citizen science took place in November 2020. The hackathon called *Put Your Language Learning in the Service of a Social Purpose!*[31] was presented by the *INOS* project[32] (*Integrating Open and Citizen Science into Active Learning Approaches in Higher Education*) and facilitated within the *DigiEduHack*[33] framework, a series of offline and online hackathons happening all around the world for two days, focusing on co-creating the future of education in the digital age. "The scope of the hackathon was to bridge language education (namely language learning and teaching) with citizen science as a form of social participation (Buunk, 2020)."

Technology-mediated citizen science is already established in the scientific community worldwide and is utilised by many scientific institutions and organisations (cf. Anderson et al., 2011, pp. 2–3). Given this solid tradition of online collaboration in the field and its already established platforms (cf. Bonn et al., 2018, p. 134), it can be assumed, that the threshold of adopting new methods of virtual cooperation and participation is relatively low. The online hackathon, being an effective tool to tackle challenges as well as a low-cost breeding ground for prototypes and innovative concepts, can be a helpful addition to the toolkit of technology-mediated citizen science (cf. Anderson et al., 2011, p. 2). Online-only and hybrid citizen-science projects could make use of it alike. For illustration, three use cases on different levels are being drafted on a project level, on the level of multiple projects, and the institutional level, that is, the 'meta-level'. But before, a few words on the online hackathon's limitations regarding citizen science.

5.2 Limitations of the online hackathon application in citizen science

It is important to mention that the 'classic' hackathon concept has caveats regarding citizen science, the first one is the different take on intellectual property. Usually, participants take legal ownership of their work and its outcomes at a hackathon (cf. Kohne & Wehmeier,

[31] *Put Your Language in the Service of a Social Purpose* hackathon: https://digieduhack.com/en/thessaloniki-citizenscience-inos, date of access: 28.12.2020.
[32] *INOS* website: https://inos-project.eu/, date of access: 28.12.2020.
[33] *DigiEduHack* website: https://digieduhack.com/en/, date of access: 28.12.2020.

2019, p. 28). However, a fundamental aspect of citizen science is its role in the open science and open access movements, not advocating any claims of ownership for the outcomes of a citizen-science project (cf. Bonn et al., 2018, p. 8). Another thing to keep in mind when conducting a hackathon is the risk of failure. As for any hackathon, achieving the desired outcome is not entirely guaranteed. It is advisable, that the supervisors curate the hackathon challenges in advance, as they know best what is needed for the research undertaking. They also need to monitor the hackathon progress, guiding and mentoring in a way that the projects lead to applicable outcomes. Thus, the facilitation of targeted research should not be completely dependent on the online hackathon at the beginning of such venture but can be used to revise and optimise the research approach.

Naturally, regarding their specifications, not every citizen-science project is suitable to execute an online hackathon: funds, know-how, and the time for preparation and facilitation are necessary and the project's framework is required to align with the hackathon procedure. Also, the willingness of the participants plays an important role; taking part in an online hackathon requires a high level of motivation and commitment, which some participants might not be able or want to invest. As mentioned in chapter 3.6, gaining participant commitment can be challenging for an online hackathon. However, if those resources are available, if the participants are eager to commit, and if all the other aspects fit, holding an online hackathon could be quite profitable – for the project itself as well as for all its stakeholders.

5.3 Three different use cases

When applying the (online) hackathon concept to citizen science, there is a peculiar condition which puts the distinction between external and internal hackathon facilitation into focus. As for any hackathon, an online hackathon in citizen science can be held as an internal or external event (cf. Kohne & Wehmeier, 2019, p. 8), whereas internal means that only members of the scientific institution or research team take part, and external implies that people from outside said groups can participate. If this external audience is heterogenous rather consisting of experts or scientists, by taking the elaboration in chapter 5.1 into account, the hackathon itself can be reckoned as citizen science. In other words: an external hackathon in the field of citizen science is applied citizen science (non-scientists conduct research under the guidance of experts). Following the logical implications of that fact in a wider sense, this is probably true for any external hackathon held for science-related projects regardless of what scientific discipline.

Hackathons in citizen science (internal and external) can be held for a specific research project (or multiple, similar ones), or on a meta-level, focusing the institution 'citizen science' itself. As already mentioned, considering the advantages in time and cost savings which are significant to public-funded ventures as well as its benefits regarding accessibility, the online hackathon offers great utility for citizen science. How this could look like is illustrated in different use cases below.

Single-project hackathon for project stimulation

On project-level, an external hackathon could help to kickstart the citizen-science project, solve bottleneck problems, find how to integrate the results and insights, initiate measurements accordingly, or blaze the trail for follow-up research. To sum up: it could stimulate the project. The aforementioned online hackathon by the *INOS* project counts into this project-focused category, given the hackathon's aim was to contribute to the whole of the *INOS* citizen-science venture.

Especially at the beginning of a project, an (external) online hackathon can help to prepare the citizen scientists for their tasks and give them first hands-on experience in the matter. Instead of facilitating usual constructive groundwork for citizen-science projects (cf. Bonn et al., 2018, p. 130) via traditional introduction sessions, briefings, and workshops, all one by one, a hackathon could include those sessions and add further benefits. It offers a more compact and holistic kick-off to a project, allowing participants to already realise their own ideas and integrate them, participating in the project full-on from start. As a side effect, a sense of community and potency is also being created. This could happen over one weekend, at which the participants – divided into teams – frame the research question and set their goals, conceptualise the research approach, develop prototypes such as measuring and observation devices, or network with experts in the field – all mentored by the supervising scientists (cf. Bonn et al., 2018, p. 125). As mentioned, the whole event is accompanied by workshops, that provide the citizen scientists with background knowledge around the object of research, and social events, for team building and networking. Also, a hackathon at the very end of a citizen-science project could be beneficial. The hackathon could focus on how to integrate the data and results, which could lead to new follow-up projects such as prototypes or applications. Also, external people, who have not been involved in the project thus far, could be invited to such events, bringing in new perspectives.

A concrete application of the former elaboration could look like this: an ornithology project is aiming to observe local bird wildlife by the help of citizen scientists at some place in

Europe, say Finland. Before the actual research period starts, the supervising scientists decide to organise an online hackathon. Not all citizen scientists who want to take part in the actual bird observations are willing to participate in the hackathon, given the common differences in willingness or availability regarding commitment to the project (cf. Bonn et al., 2018, p. 132), but a motivated set of 20 hackers can be put together. Divided into four teams of five, the teams try to tackle the following research project-related challenges: the methodology of the observation phase shall be optimised accordingly to manpower, equipment, local scenic conditions, and learnings from similar research in the past. Also, some specimens shall be probed with tracking devices; given the GPS and mobile service coverage in the area is poor, one team is trying to find a solution to bridge this issue. Another group is looking into ways on how to facilitate the research most effectively under the pretence of eco-friendliness, sustainability, and scientific accuracy. Lastly, the fourth group is developing a science-communication strategy, aiming to inform the local population about the project and the observed animals. Next to the hacking sessions, there are research-related workshops, conveying basic knowledge and skills, as well as social events for team building. Not all the teams come up with full-fledged solutions, nevertheless, lots of useful work can be implemented into the research protocol, and, on top of that, the hackathon would give its participants the chance to get to know each other and delve into the matter of research prematurely.

Cross-project hackathon for collaborative advancement

Another, perhaps more experimental way to exploit the online hackathon lies in including multiple, similar citizen-science projects in the same field for the event. For the hackathon being held virtually, projects from all over the world can join. The online hackathon could only address the supervising scientists (internal), or also citizen scientists (external)[34], to develop gadgets and concepts which can be universally applied to the individual research projects. The opportunity to network with experts in similar fields could be helpful for the research projects, enabling interexchange of experience and support during the hackathon and after, when the actual research is being conducted. Picking up the ornithology project-example again and applying it to this inter-project level, one could think of a global hackathon where many citizen-science projects with a focus on wildlife observation come

[34] There is even a third category to be thought of: researchers from other disciplines than the hackathon's project who partake in hackathons to broaden their scope of action. Those scientists are somewhat both external and internal. External regarding the field of research, internal regarding the scientific community itself, being familiar with its rules and workflows.

together, the Finish ornithology project being one of them. This could include projects progressed to different stages or only projects which are all about to start around the same time. Surely, each project has its own peculiar challenges, but given they are all coming from the same field, some challenges and ideas can be hacked in common effort. For example, as for the project focused hackathon, universal wildlife tracking and observation methods, as well as devices, can be developed. As well as platforms for data collection, analysis, and comparison. Also, concepts for wildlife protection and science-communication strategies can be investigated.

Self-referred hackathon

A third application of the online hackathon in the domain of citizen science could be a hackathon that focuses on the field and its necessities itself. Such a 'meta-hackathon' on an institutional level could bring together citizen scientists, professional scientists, and even further entities. Together, they tackle interdisciplinary challenges related to the general concept of citizen science. Those challenges could range from improving communication practises to implementing new technologies, from optimising participant acquisition to establishing better project fundraising, from furnishing new participation models to exploring new fields where the citizen science model can be applied to. For example, the *ECSA* could organise an online hackathon to improve online collaboration in citizen science. The challenges, coming from different departments from *ECSA* and other institutions, ranging from conceptualising a uniform mobile application for ornithology projects, developing a crowd computing platform for medical research, or drafting an initiative to make citizen science more popular among students. Participants could be seasoned citizen scientists, scientists, marketing experts, developers, designers, psychologists, policymakers, etc. The online format allows people to join from all over Europe and connect for two days, sharing their experiences, doing some networking, etc. In addition, this mode of driving innovation in the field makes the citizen-science endeavour even more democratic and sustainable, whereas the online hackathon incorporates it as a citizen-science project of its own.

6. Conclusion

The online hackathon phenomenon is a good example that "[…] so far the Internet's [sic!] civic potential has been greater than its use" (Blumler & Coleman, 2001, p. 14) – an observation made 20 years ago, yet still valid. Furthermore, the online hackathon is one of

the rather ‘beneficial developments’ resulting from the ongoing Covid-19 pandemic and given its success, one can assume that it will prevail even after the pandemic has ended and on-site hackathons are possible again. Being an interesting phenomenon in many respects, its vast potential in driving innovation, bringing people together, and allowing participation renders the online hackathon a phenomenon worth to be better understood. The introduction of the hackathon concept into the online environment already took place a couple of years ago, however, its full potential has never been played out until the beginning of the Covid-19 crisis. The timeframe of the online hackathon event seems crucial: ‘long-term online hackathons’, that is ‘coding challenges’, and short-term online hackathons of about 48 hours, which are closer related to the physical hackathon, coexist. Both have their benefits and drawbacks as well as their suitable applications. Nevertheless, a terminological and typological distinction is necessary to further enable discourse and development of the hackathon concept’s nuances. The description of the online hackathon as a virtual adaptation of the ‘traditional’ hackathon concept furnished in this work hopefully serves future investigations into the topic as a valuable point of reference.

After seeing the successful facilitation and project outcomes of online hackathons during the Covid-19 pandemic in 2020 and thereafter, one can assume (and hope) that, in future, online hackathons will be considered as an instrument to find innovative solutions.

The online hackathon might not be the most elegant way of collaboration, given the social and collaborative drawbacks, but it offers great possibilities in harvesting crowd intelligence facilitated by its low-threshold accessibility and scaling which also promotes e-democratisation and enables more economical and ecological collaboration. This underlines once more the significance of the hackathon as an instrument the whole of society can benefit from. Despite strong benefits and promising chances, the online hackathon also holds considerable drawbacks and tough challenges. For some projects, an online hackathon might not be suitable, especially for hackathons with special emphasis on social aspects such as team building, networking, or learning. An online hackathon can definitively foster and support such aspects. However, a physical event excels in this regard and seems to be the more appropriate option. Consequently, comparing the efficacy between physical and online hackathons is an interesting subject for future research in this field. This can be probed in many respects, such as the quality of the outcomes, the participant’s experience, or the reached goals set by the host. Also, it might be interesting to see whether the accessibility advantage of the online hackathon actually takes effect. That is, whether online hackathons generate a broader spectrum of participants and higher applicant numbers than on-site hacks.

And the question, whether projects that originated in an online hackathon are more likely to be pursued since participants are already accustomed to online collaboration, seems intriguing and worth being investigated as well. Whatever further research regarding the online hackathon may look like, it seems evident that the concept will be developed and improved further. The directly profits directly from future findings and developments in the domain of online collaboration and remote work in general, which has skyrocketed due to the ongoing global pandemic (Statista, 2020).

As shown in the last chapter, the scientific community, with citizen science serving as an example, holds suitable ways of application for the online hackathon concept; many fields can take advantage of this event type. Next to academia, the public sector can profit from the online hackathon, enabling citizens to participate in democratic processes, as the hackathons related to the Covid-19 pandemic have shown. Furthermore, companies or whole business sectors could take advantage of online hackathons. Regarding the online hackathon's use cases, what we have seen so far was merely the tip of the iceberg, with many new applications yet to come.

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8. List of figures

9. Declaration of Honour

I hereby ensure that this work is a product of my own and that I marked all references and expedients for its creation adequately. I am aware that a proven act of deception can bear legal consequences.

Karlsruhe, 15.02.2021