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Hacking the hackathon format to empower citizens in outsmarting "smart" cities

Tomasz Jaskiewicz[1], Ingrid Mulder[1], Nicola Morelli [2], Janice S. Pedersen[3]

[1] Delft University of Technology, Faculty of Industrial Design Engineering, Landbergstraat 15, 2628CE Delft, the Netherlands
[2] Aalborg Univeristy, the Technical Faculty of IT and Design, Rendsburggade 14, Building:5358, 9000 Aalborg, Denmark
[3] Independent researcher, Copenhagen, Denmark (formerly Anthropologist at Antropologerne ApS)

Abstract. This paper investigates the opportunities of leveraging a hackathon format to empower citizens by increasing their abilities to use open data to improve their neighbourhoods and communities. The presented discussion is grounded in five civic hackathon case studies organised in five European cities. The research revealed specialised learning and collaborative alignment as two mutually complementary aspects of the involved learning processes, which were achieved with the help of high-fidelity and low-fidelity prototypes, respectively. Consequently, the paper identifies and discusses three main factors required to sustain social learning ecosystems beyond hackathon events, and with the purpose of democratising smart city services. These factors include a) supporting individuals in obtaining specific expert knowledge and skills, b) nurturing data-literate activist communities of practice made up of citizens with complementary expert skillsets, and c) enabling members of these communities to generate prototypes of open-data services of varying fidelity.

Keywords: learning through making, hackathons, open data, prototyping.

1 Introduction

Smart cities need smart citizens [14][15][25]. The discourse on "smart learning-ecosystems" provides a conceptual framing to recognise the "presence of a high density of high-skilled people in a given area" [13] as an indicator of a city's "smartness". On the whole-city level such performance is influenced by factors such as the quality of education or city governance. Yet, taking a closer look at specific citizen communities reveals peer interactions among citizens as a source of new or improved skills and abilities. Rather than being driven by explicitly formulated learning goals, these peer learning activities are often motivated by citizens' basic, core needs for autonomy, relatedness and mastery [8]. Close attention to citizen communities also emphasises the plurality of citizens' skills and motivations as a key factor of the community's capacity building enabled through diffuse design [18]. In this paper we explore the opportunities of leveraging learning processes happening during civic hackathon events, as catalysts for self-directed learning in citizen communities.

Hackathons are fast-paced events where teams of participants “hack together” prototypes of existing or new services, apps or products [2][22][29]. Civic hackathons are an increasingly popular kind of hackathon, aimed at improving city services and citizen–government relationships, and promoting the use of government-published open data [17]. Unlike regular hackathons that cater mainly to software developers, civic hackathons welcome a more diverse crowd of participants. For example, Code for America [5] is an organisation running dozens of civic hackathons each year throughout cities in the US, each generating dozens of app and service concepts and prototypes. Applications developed in civic hackathons include innovative services addressing various aspects of people’s lives. Examples include mapping health-related resources and services in an urban area, providing community members with legal advice, or finding vacant properties that are suitable for local businesses [23]. While there is clear value in civic hackathons as sources of such applications, in this paper we focus on another, underrepresented advantage of civic hackathons, namely their role as loci for peer learning. From this perspective, citizens participating in civic hackathons not only do so to be provided with solutions to their problems, but also to acquire the capacity to solve civic problems through the use of open data. In the presented work, we seek to answer the question of how to “hack the hackathon format”, such that it can better support citizen communities in obtaining the ability to work with open data, and, thereby, how to empower groups of citizens to outsmart the “smart cities”?

The premise of the hackathon format is that the participants’ focus on the “making” of concrete services or products involves a learning-by-doing [10] approach, where the created solutions function as boundary objects [28], reducing communication overhead, and enabling peer-learning through showing and experiencing ways of doing things. Joint making activities, as identified by Giannakos et al. [12], a) accelerate research across involved disciplines, b) promote rigorous multidimensional and multidisciplinary, methods, experimentation strategies and metrics, c) facilitate easy starts of ambitious projects, and d) enable (applied) learning through construction activities. Such forms of learning are commonly practiced not only in brief events such as hackathons, but also over longer periods by maker communities in places such as Hackerspaces, Makerspaces or FabLabs [16]. The premise of these places is not only to allow for the collaborative making of prototypes, but also to accelerate and catalyse the learning processes of involved people. In the contexts of these places, communities of practice [32] emerge where participants share skills with each other and perform routines of collaboration. However, in civic hackathons, participants are diverse in that they don not share professional backgrounds, and they have only limited time to establish a community of practice within the event. In this context, we expect there to be a divide between “professionals” with clearly defined expertise or roles relating to the theme of the civic hackathon, and “laypeople citizens” interested in the theme itself. We hypothesise that engaging laypeople citizens in activities involving “prototyping with open data” can have a two-fold effect. On the one hand, “laypeople citizens” may not have technical coding or design skills, but are “experts in their lived experience” [26] within the local context and challenges. In that way, in the spirit of co-creation [26], “professionals” can learn from “laypeople citizens” about the intricacies of the context they develop solutions for. On the other hand, “laypeople citizens” can learn from "professionals" about the opportunities of working with open data and developing open data driven services, apps and products, empowering them in the context of smart cities [30].

The goal of the presented work has been to understand the general principles governing peer-learning in citizen hackathons, and to explore facilitation mechanisms for increasing the community's capacity to work with open data. To this end, as part of a consortium of the Horizon2020 CAPSSI (Collective Awareness Platforms for Sustainability and Social Innovation) project Open4Citizens (O4C), we have organised a series of civic hackathons in five large European cities. We have defined the civic hackathon as a 2-3 day "pressure-cooker" event actively involving citizens with no prior knowledge of coding or other data skills in joint making of a preliminary prototype of a technological product or service, using one or more forms of open data.

By executing and analysing the learning processes of participants in these events, we aimed to understand the potential of prototyping with open data as a social learning activity [1]. Accordingly, in facilitating the process, our focus has been split between understanding a) the discovery of new opportunities of meaningful open data applications in a civic hackathon context and b) identifying ways to support bottom-up, community-driven learning and sharing of data literacy skills, such as data scraping, basic data analysis or understanding opportunities and constraints in embedding a dataset in a service or app.

2 Methods

Exploring learning processes in civic hackathons is uncharted territory within academia. Scarce literature on learning in regular hackathons, for example [11], takes the perspective of supporting the learning of well-defined programming skills. In civic hackathons, however, the emphasis lies on combining and improving a wide array of skills by working together across disciplines in contexts that may vary greatly across cultures, and between communities involved in the hackathons. For that reason, our studies were set up in an explorative way, leveraging semi-structured observations and interviews as the main method of enquiry, standardised across five civic hackathon cases.

The five civic hackathons were organised under the auspices of the O4C project in Barcelona, Copenhagen, Karlstad, Milan and Rotterdam. The organisation and facilitation of the events was performed by local O4C consortium members (the *pilot team*) in collaboration with local stakeholders, including, among others, citizen groups, local governments, non-governmental organisations and universities. The general guidelines for the O4C civic hackathons were predefined by the O4C consortium members and provided to individual pilot organisers in the "hackathon organisation handbook". The handbook specified the shared elements of the hackathon process. It indicated the actors to be involved in the process (from citizens, to public authorities, from experts to interest groups), the phases of the hackathon process, the tools to use in the various phases, as well as other practicalities in the organisation of the hackathon. The 2-3 day civic hackathon event was preceded by a "pre-hack" phase (3-4 months) where, among other activities, the theme for each hackathon was defined, participants were recruited, and relevant datasets were collected. Each hackathon was superseded by a "post-hack" phase (4-5 months), where various forms of support were given to hackathon participants to continue developing solutions initiated in the hackathon and in order to sustain the community established throughout the pre-hack phase and the hackathon event.

The organisational setup of the actual hackathon event has been inspired by IDEO's inspiration-ideation-implementation process [3], as summarised in Figure 1. Its steps included open data introduction, sharing inspiration, articulating needs to be addressed, brainstorming, data validation, exploration of data using a dedicated platform and toolkit, scenario design, prototype planning, prototype hacking and pitching final concepts and prototypes in a plenary session. For each of the steps, process facilitation tools were prepared (Table 1). One or more data exploration and data analysis platforms were accessible to support the whole process. At the same time, the process facilitation was prescribed but with some flexibility, allowing individual hackathon organisers to adjust it to local specificities and to the interests and prior skills of participants.

Table 1. Civic hackathon processes were facilitated with the help of a range of tools.

Phase	Tool used
Open data introduction	Presentation (examples)
Inspiration	Inspiration cards
Need definition	Need definition cards and need definition canvas
Brainstorming	Brainstorming tool (ideas mapping, opportunity question, idea selection, idea specification)
Data platform use	Data platform
Data validation	Data cards, Data booklet
Scenario design	Scenario template
Prototype planning	Prototype planning canvas
Pitching	Pitching canvas

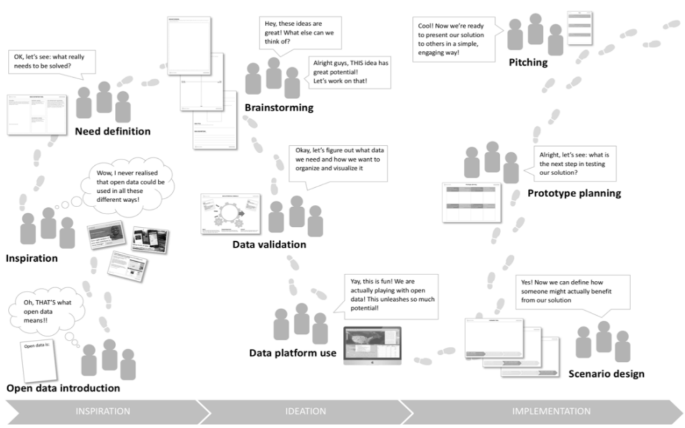

Fig. 1. The civic hackathons followed the inspiration, ideation, implementation process, while being supported by dedicated process facilitation tools and an online platform for accessing and working with data.

Throughout each of the O4C civic hackathon processes, data on these processes was collected in a standardised way across all events and recorded in a variety of forms. Methods for collecting process data included surveys of participants, carried out before and after each hackathon. The work process of all teams was observed and noted, as well as photographed and/or filmed throughout the event by designated researchers. The aim was to capture group dynamics, the process of collaborative solution development, and the mood of the participants, including 'ah-ha' moments where groups' progress towards the development of a concrete solution surged forward. Participants were interviewed during the event to further explore their motivations, and the skills and experiences brought to the event. In addition, where relevant, participants' interest in and knowledge about open data was explored further through additional interviews. The process data was collected in order to understand hackathon participants' learning experiences in light of their backgrounds and skills, motivations for participating, their individual experience of the hackathon process and their perceived gains from the event.

The hackathon process data gathering was guided by the facilitation support scheme shown in Figure 1, whose standardised format was specifically tailored to the O4C hackathons and to the hackathon activities through which the participants were steered by event facilitators. Captured data was organised according to process stages, in templates standardised across all the O4C hackathon cases. Hackathon results including designs and prototypes were documented visually, catalogued and shared with the participants. Subsequently, collected data was transcribed where necessary, and analysed by teams of consortium members local to each hackathon, including coding and clustering. By distilling and capturing resulting insights in the shared format, pilot teams were able to capture and compare participants' learning processes in hackathons. The individual experiences of participants and facilitators working to create open-data-related solutions were captured and translated using significant quotes and visuals. This standardisation of data capturing and analysis across all five hackathon cases enabled comparison of performed processes. Such comparison led to insights into opportunities and challenges in tailoring a structured hackathon process and toolkit to contexts with different thematic challenges, varying skills of facilitators and stakeholders, a range of participant motivations and variable quality of available inputs, including open data. Further, the collected data has also allowed for an assessment of how the given factors influenced the individual and collective learning processes of hackathon participants. The described data has allowed us to further outline a number of trends related to social learning in civic hackathons.

3 The five O4C civic hackathons

3.1 Participants

Participants' profiles were determined based on participants' self-declared expertise or/and self-declared role in an organisation. This data was captured in sign-up questionnaires with further elaboration through conversations during the hackathons, recorded either through notes, audio or video. Table 2 shows an overview of the distribution of participants belonging to seven resulting generalised profiles across pilot locations. The distributions reveal significant differences between the participants in the five hackathons. For example, the Rotterdam hackathon involved mainly theme experts, citizen activists and municipality representatives and no (professional) coders, while the Milan hackathon mainly involved coders and designers. These differences can be attributed, on the one hand, to different participant-recruiting strategies, and, on the other hand, to different ways in which participants chose to self-declare their expertise, depending on the cultural context and self-perceived role in the attended event.

Table 2. Distribution of participant self-declared identity in hackathons.

	software and hacking	deisgners / design thinkers	citizen activists	theme interest/experts	business / entrepreneur	data experts	officials/municipal
Barcelona	30%	8%	23%	16%	13%	13%	7%
Copenhagen	21%	21%	21%	19%	9%	6%	
Karlstad	16%	20%	5%	12%			32%
Milan	40%	40%	14%				4%
Rotterdam		8%	25%	42%			25%

Recruitment of hackathon participants and partners has leveraged existing networks within which the local organisers operated. For example, prior engagement of local organisers with a range of citizen activist groups in Barcelona and Rotterdam allowed for these groups to be well represented in those hackathons. Similarly, in Karlstad and Milan, the organisers' familiarity with local designers and design thinkers, led to substantial involvement of these groups in the hackathon. In addition, there has been a long-recognised need in Milan to open up public sector data and make it available in an accessible format; the need to open up public sector information had already been addressed in other involved cities. This required additional focus on the technical skills in the Milan hackathon and substantial effort was made to recruit individuals with software and hacking skills.

3.2 Process

The process of the hackathons involved a mixture of activities. In all cases the facilitation was carried out flexibly. The facilitation scheme in Figure 1, for instance, was considered as an orientation map, rather than a prescriptive sequence of phases, and the facilitators were free to use other tools (like customer journeys or templates) that might be more familiar to them. The flexible facilitation resulted from pragmatic decisions by the pilot teams about how best to support a good experience for participants as well as learning about the process and the development of solutions to challenges posed within the time available. Table 3 summarizes the resulting key differences between hackathons.

As a result of facilitation adjustments, the hackathon processes in Barcelona, Copenhagen and Karlstad resembled fast design sprints, with concepts being designed on paper during the implementation phase. The Milan hackathon process was the closest to a typical coding hackathon, while the Rotterdam hackathon involved mainly conceptual and open-ended designs, albeit converging in concrete sketched design concepts at the end. In most cases, use of open data was limited to finding inspiration in descriptions of other open-data-driven solutions and in descriptions of the available and possibly useful open data sets. In some cases, inspiration was found in performing ad-hoc data visualisations and analysis, or simply browsing through available datasets and discovering intriguing facts. The post-hack phase was in all cases considered as the phase in which the concept could be implemented, using the most appropriate datasets.

Among participating teams, two distinct types of activities were observed in all hackathons. Many teams engaged in extended "discussing" of topics related to the hackathon theme and their design response to it, where views and ideas were shared and the team's direction determined. This type of activity typically took place with all participants assembled around a table, whiteboard or flip chart, as shown in Figure 2. Plenary presentations of teams' work, performed in some cases during, and in all cases at the end of the event, were a special form of "discussing". During plenary presentations teams had an opportunity to exchange views and ideas, as well as share technical approaches or data findings, and in this way influence each other's work.

Fig. 2. The hackathon processes consisted of different types of participant activities, interchangeably involving various forms of "discussing" where the entire team was involved, or "focusing" activities involving various forms of making, where team members would work on different, specific tasks.

Table 3. Each of the organised civic hackathons had a unique set of characteristics.

Location	Theme	Deviation from the facilitation scheme	Days	Participants
Barcelona	Urban public health, neighbourhood services, access to local culture	Altered order of activities	3	84
Copenhagen	Refugees, immigration & integration	Open, playful atmosphere, a facilitated session on fast prototyping	3	28
Karlstad	Healthy living in Kronoparken district	Inspirational lectures	3	35
Milan	Transparency on urban transformation	Prizes for best output, 15 data experts supporting, but not directly participating in the hackathon, high involvement of design and IT students	2	73
Rotterdam	Self-management of parks	Focus on data-articulation, flux of people joining / leaving during the course of the event	2	42

Team members also performed “focused” activities. These activities typically entailed some form of making, either performed as drawing, writing or coding, but always directed towards producing a form of concrete representation or prototype of a designed solution or its part. During such activities, participants focused on specific tasks, such as drawing a screen layout, a diagram or a scenario, browsing through data, or writing a snippet of code. During some moments of “focusing”, every team member performed an individual activity. At other times, one person would work on a task and one or more of the other participants would look over that person’s shoulder, trying to understand and follow that person’s activity, making comments and asking questions, and in this way familiarise themselves with the skills and know-how involved.

The “discussing” and “focusing” activities were performed iteratively in hackathons. The organisation of the hackathon influenced some of these iterations by limiting their time, although the number of iterations between forced presentation moments or breaks varied by team and hackathon. The time duration ratios between “discussing” and “focusing” varied significantly between hackathons. Although no exact account of the duration of these activities was recorded per team, a general comparison is possible based on our observations. For example, in the Rotterdam hackathon mainly “discussing” took place with only short (approximately 5 minute) intervals of “focusing”. In Milan, “focusing” was the dominant activity in the middle of the hackathon, with “discussing” mainly taking place at the outset of the event. In the Copenhagen hackathon, the “focusing” elements were integrated around plenary presentations of tools by the facilitators and organisers or of work in progress by the teams of participants.

3.3 Outputs

Assessment of artifacts generated by hackathon participants revealed the intricacies of the performed processes. On the one hand, the teams generated various forms of written notes throughout their process, typically using post-its, at times without structure, and at times using some of the prescribed facilitation formats. This documentation, mainly intended for internal communication within teams, showed the dynamic nature of the processes and the mix of ideas from various domains intertwining with each other. On the other hand, the teams also generated various forms of service design representations and prototypes, which provided a more legible, albeit indirect, account of their processes. Design representations and prototypes varied significantly in their forms across hackathons, which can be attributed to differences in team compositions and facilitation. However, we could generally discern two types of prototypes and design representations, following their correspondence with earlier discussed “discussing” and “focusing" activities of participants.

The first type of representations and prototypes was typically made together by entire teams during the “discussing” activity, and can be characterised by their low fidelity. These representations and prototypes were made quickly using ad-hoc techniques. Figure 3 shows one example, a “paper prototype” [27], developed during the Rotterdam hackathon. Such prototypes are make-believe sketches of an app interface made on post-its attached to a mobile-phone cardboard mockup. Paper prototypes are almost instantaneous to make and can be used to crudely explore app functions and communicate them within and outside of the team. Figure 4 shows another example of the same type, where a user scenario was explored and enacted using lego blocks during the Copenhagen hackathon. Similarly to a paper prototype, such a representation of a service allowed the team to both explore and rapidly validate the intricacies of the designed service as used in various contexts.

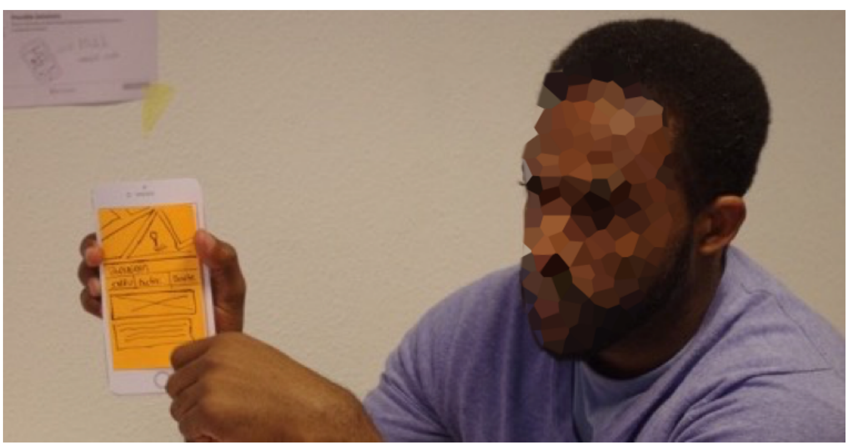

Fig. 3. In the Rotterdam hackathon paper prototypes were used during team discussing to elicit overlooked issues and design repercussions, and ensure shared understanding of the direction in which the team was heading.

Fig. 4. Lego blocks provided a fast method of representing and enacting possible use case scenarios during the Copenhagen hackathon.

The second type of representations were high-fidelity drawings, models and prototypes, made during “focusing” activities, typically not involving extended cooperation in the process of their making. Such representations and prototypes had different roles depending on the phase of the hackathon. Initially, they could only address a narrow aspect of a possible solution, for example, by making a visualisation of a subset of available data using a spreadsheet program. Later in the process they were combined into high-fidelity prototypes and detailed representations of designed services, providing a believable outlook of how a designed service might function and feel. Figure 5 shows an example of a website mockup generated during the Barcelona hackathon that fits in this category. Here, various parts created by different participants were integrated in a way that could provide an experience of using the designed service. Such prototypes were used during the final round of hackathon presentations in order to show how attainable the concepts were and that their further development would be useful.

In all cases, participants used the final prototypes and design representations as tools to tell the story of the specific city problems on which they had worked during the hackathon and to explain their visions of how these problems could be addressed. However, the way in which the different types of prototypes were integrated in teams’ activities clearly differed; they either dynamically elicited discussions and explorations of a topic, or consolidated teams’ conclusions, individual work and individual expertise to represent and communicate a single design solution.

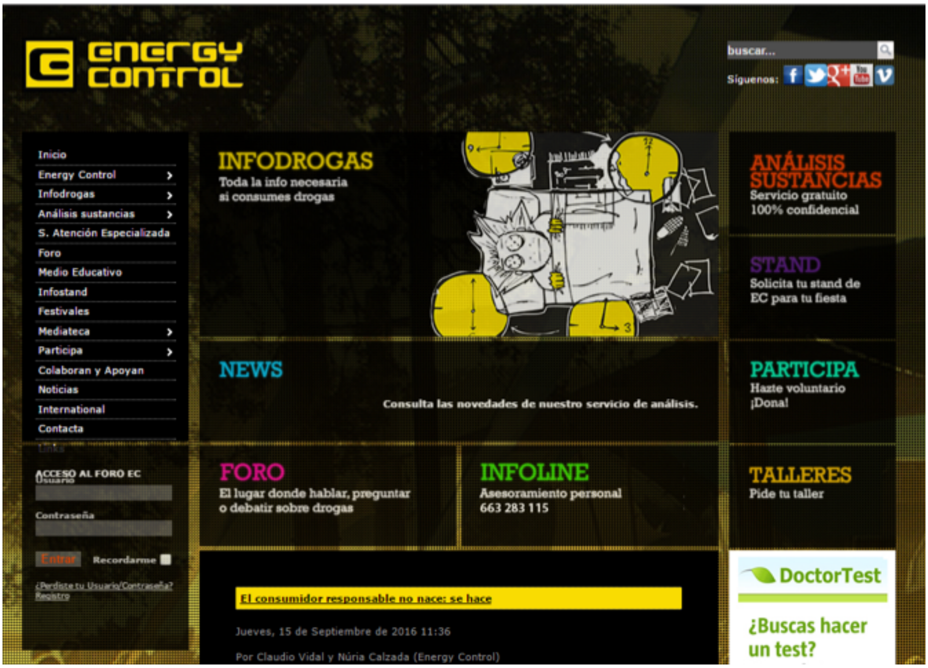

Fig. 5. Detailed website mockups were presented at the end of the Barcelona hackathon, consolidating individual team members' work on different parts of the prototype.

4. Results

The twofold goal initially formulated for the O4C civic hackathons was to support citizens in a) discovering new opportunities of meaningful open data applications and b) bottom-up, community-driven learning and sharing of data literacy skills. The two goals have proven to be tightly interlinked. The open data applications, whether instantiated as low-fidelity sketched ideas, or high-fidelity working app prototypes, functioned as boundary objects in the hackathons. They supported the consolidation of participants' skills and ideas, confronting these with the world, as well as communicating and reflecting on them. Consequently, the open data applications have also supported the learning and sharing of data literacy skills. As such, they helped reveal different competences involved in the hackathons and participants' different expectations. The learning processes at hand have also proven to be more complex and difficult to measure than initially expected, as they differed considerably between participants and cases. This complexity of measurement was also reflected in the different criteria proposed for measuring such goals. The O4C team had clear and quantitative criteria regarding the number of viable concepts developed in the hackathons and the number of startups or entrepreneurial initiatives triggered by each hackathon. On the other hand, the learning objectives were only qualitatively defined, on the basis of the pre- and post-hack interviews that provided information about initial skills and expectations and about new skills and knowledge acquired during the hackathon. Such qualitative evaluation is also influenced by the different cultural backgrounds and on the diversity of skills among participants in the same team.

4.1 The learning outcomes

The heterogeneous mix of knowledge brought by the participants to the hackathons and the varying conditions of accessibility of open datasets has made it difficult to perform a quantitative evaluation of the learning outcomes of this process. The participants' learning expectations were in fact related to their motivations for participating. In addition, different types of participants (public servant, start-ups, curious citizens or interest groups) had different motivations, as summarised in Figure 6. Interviews with the participants were not carried out assuming that these motivations corresponded to learning objectives. Instead, the interviews aimed to define the effectiveness of the hackathon as a tool to address the participants' expectations regarding open data. Aspects considered in the interviews were not only related to the use or disclosure of the data, but also to the systemic effects that the hackathon can trigger in the process of innovation.

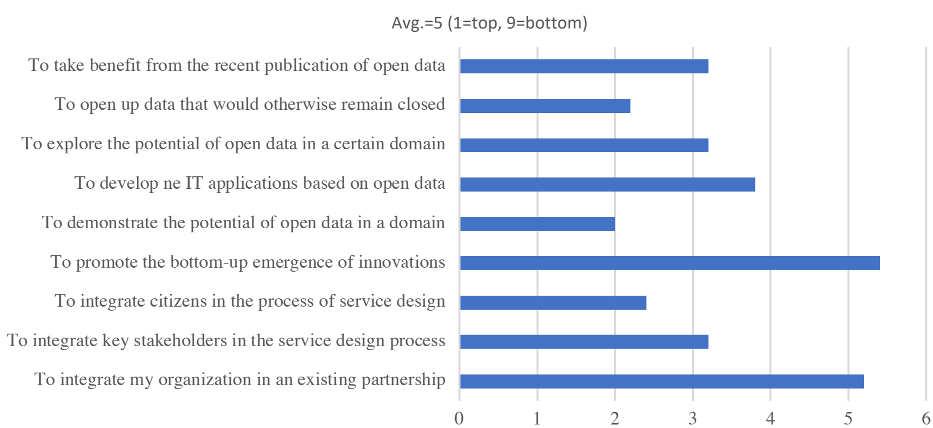

Fig. 6. Surveys indicated large disparities in participants' expectations towards hackathons and their level of fulfilment.

The interviews revealed two ways in which participants experienced learning during the hackathon process. First, the majority of participants confirmed that in some ways they have acquired new knowledge regarding the expected learning domain. For example, a participant interested in understanding the potential of open data, learned about the existence of several relevant open data sources, and their application to his area of interest. Second, most participants indicated that their most valued learning experiences lay in learning unexpected things. For example, one of the civic activists indicated that she came to the hackathon to find resources for her project in the city budget, and instead she learned how to use open data to build a business case for the community project independent of city funding. Yet, above all, the majority of participants have indicated that the main benefits they saw in joining the hackathon was in the social connections they made, developing mutual understanding of each other's skills and goals, and an expectation that the team, working together, will be able to continue their joint work after the hackathon. In this way, the increased capacity of the community to work with open data is larger than the sum of individual learnings of the participating community members, and is evidenced by open data applications generated in the hackathons.

Table 4. The open data applications developed in the civic hackathon cases involved varying levels of fidelity.

O4C hackathon event by location	No. of concepts developed	Level of development at the end of the hackathon event	No. of viable concepts developed after the hackathon	No. of startups created after the hackathon
Barcelona 1	5	Prototype	3	2
Barcelona 2	6	2 concepts 4 mock-ups	0	0
	6	4 mock-ups 2 prototypes	2	2
	5	2 concepts 2 mock-ups 1 prototypes	0	0
Milan 1	11	5 mock-ups 6 prototypes	1	0
Milan 2	5	5 mock-ups	1	0
Rotterdam 1	5	Concepts (realized as mock-ups and prototypes)	1	0
Rotterdam 2	3	Concepts (as pitches and video presentations)	0	0
Karlstad 1	4	Concepts, prototypes	2	0
Karlstad 2	5	Concepts	0	0
Copenhagen (DNK)	6	Concepts	(2)	0
Aalborg (DNK)	11	Concepts, mock-ups, 1 early prototype	1 (4)	1

4.2 Open data applications

The hackathon activities across the various pilots generated a number of concepts, with different levels of maturity, ranging from sketched ideas to working prototypes. Table 4 synthesises the results of the hackathons. The number of start-ups created after the hackathon is an additional metric, indicating where the relevance and maturity of developed applications was high. Within the distinction of 'level of development' between 'concepts', 'prototypes' and 'mock-ups' reported in Table 4, there were some further disparities. For instance, some hackathons only developed paper prototypes, whereas others developed high fidelity prototypes. Also mock-ups had varying levels of detail. Some of them were used as proof of concept for presentations in the post-hack phase, whereas others were the starting point for the construction of apps that were further developed up to the commercial stage.

The further qualitative analysis of open data applications not developed as part of the O4C project has revealed the potential of these applications to increase the capacity of involved citizen groups to leverage open data to learn and meaningfully transform their city outside of the time-frame of hackathon events. For example, a prototype app for mapping valuable trees across the city promised to further spread the knowledge and awareness about the importance of natural ecosystems in cities and gives citizens a tool to actively protect that ecosystem by taking collective action to protect trees when needed, and based on facts rather than emotions. The diversity and richness of the opportunities coming from such applications prompts a more open discussion of the opportunities of civic hackathons, not just as one-time learning and capacity building events, but also as parts of learning ecosystems at a larger timescale.

5 Discussion

The results of the presented civic hackathon case studies have enabled us to derive considerations about the nature of the learning processes involved. We have structured these considerations based on the four perspectives of a) individual learning, b) community capacity building, c) learning through prototyping, and d) civic hackathon facilitation.

5.1 Individual learning perspective

The individual learning perspective was evaluated through interviews conducted before and after each hackathon, which gave the O4C project team a chance to compare initial expectations, skills of participants and the actual experience of participants in the hackathon. The five hackathons took different approaches towards recruiting participants and responding to the hackathon themes. As a result, the distribution of participant types has varied considerably across the hackathons. This has led to different hackathon profiles and differences in the characters and roles of created prototypes. For example, the Milan hackathon had the highest turnout of coders, and prototypes included snippets of working code and detailed app mockups. On the other hand, the Rotterdam hackathon mainly involved citizen activists and municipality employees, no code was developed and prototypes were limited to paper app mockups. In the first case, participants were able to improve coding skills, while in the latter the focus was mainly on developing conceptualisation skills.

The interviews with participants and post-hackathon surveys have revealed a different perspective than analysis of participant activities and prototypes alone would indicate. The first trend was for participants to question the non-nuanced classification of their own expertise. For example, several municipality employees emphasised that they are also regular citizens, one indicated that coding is a hobby of his. To give another example, the differences between designers and coders were often difficult to clearly articulate, as many designers had some coding skills, and many coders had experience in app design. Most participants also demonstrated design and creative thinking capabilities, even if they indicated they did not have any. The other trend was for several participants to indicate that their perception of the social or institutional group they represent is that it is composed of individuals of very diverse skills, motivations, characters, and underpinning values. For example, a municipality worker in the Rotterdam hackathon said "Citizens see municipality as one thing, while there are many very different people working there. At the same time, municipality workers see citizens as one mass of people, without understanding the differences between individuals." The third trend was that there was rarely a single, clearly articulated motivation for each participant to participate in a hackathon. Participants typically stated only very general motivations such as a) improving one's (either broadly defined, or undefined) skills by applying them to a practical case, b) learning new skills from others, or c) only indicating general curiosity in the hackathon's theme and/or open data. The above trends allow us to conclude that strong profiling of participants is to a large extent futile in the context of a civic hackathon. Participants generally shared a lack of explicitly articulated motivations to participate in the hackathon, while they exhibited multiple combinations of prior skills and abilities during the hackathon itself, and the roles that individuals eventually assumed in their teams were dynamic and organic throughout the processes.

The above insights have inspired us to use the T-profile of a designer popularised, by Tim Brown [3], to summarise these insights for further reflection. In the T-profile, the vertical leg of the letter T symbolizes one person's core expertise and the horizontal bar represents their general overview of other knowledge. Figure 7 uses the T-profile metaphor to indicate three learning opportunities that we have observed among hackathon participants, independently of the specifics of their core expertise(s). Red arrows indicate enhancing existing core expertise. Green arrows indicate developing new expertises during a hackathon. The blue arrows indicate gaining a broad view of opportunities coming from the skills of others, i.e., getting "a taste" of diverse skills and knowledge involved in the design and development of an app or service. The advantage of this model is that it does not specify what the core competence of the hackathon participant is, only that there is one, while differentiating between learning that may occur within that competence, regarding other expert competences, or on a very broad level.

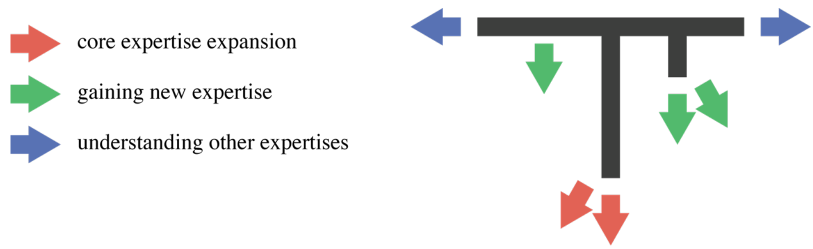

Fig. 7. The knowledge profile of a civic hackathon participant can be represented as an extended T-profile, which allows one to indicate three types of knowledge gains that participants experienced independently of their prior expertise.

5.2 Community capacity building

The formulation and evaluation of the community capacity building perspective is based on pre-hack and post-hack interviews. The hackathon pilots were organised with a premise of supporting citizens to learn data-related skills, while developing meaningful solutions to problems found in their city. However, in the post-hackathon feedback, participants indicated that learning about other participants' views, improving their ability to work in a diverse team, and gaining new perspectives on the city's problems were the learning outcomes that they valued the most. Furthermore, we have observed that while jointly working on solutions, participants' views of the problem they were facing, and ways in which they were articulating their city-related values were also transforming. For example, in the Rotterdam pilot, one participant changed the attitude towards the city from "it's their job [as a municipality] to support our park financially" to "we should come up with a business plan for our park that we could pitch to the city [officials]". Consequently, understanding and taking advantage of involved social learning [1] happening between participants, and resulting alignment of their values and perspectives, called for a deeper investigation in an attempt to explain its root causes and mechanisms. Another aspect concerning social learning was the growing perspective on open data as a new resource for public innovation or a new commons [21]. The elaboration of this perspective was purely conceptual in Rotterdam, where the hackathon produced concept prototypes, whereas it brought about a concrete application in Milan, where a specialised prototype was further developed and integrated in the existing web portal that informs citizens about the construction of the new metro line.

In their discussion on constructivist and sociocultural perspectives on learning, Packer and Goiocoechea [24] conclude that "acquiring knowledge and expertise always entails participation in relationships and community and the transformation of the person and of the social world" where "the person is constructed in a social context formed through practical activity (...)". We can expand this general perspective on learning in a community by considering the notion of shared cognitive models. As Cooke et al. [6] argue, shared cognitive models develop through interactions between team members, and enable teams to address problems in synchrony. We will further refer to such synchrony as "collaborative learning alignment", as it can be applied to situations where not only teams, but also other, more fluid forms of collaboration can take place. The above view of the intrinsic nature of "social learning" matches our need to consider hackathon participants' identities not only as being unique, but also as actively evolving, aligning with each other, and stimulating each other's growth throughout the execution of the making activities during hackathons. This kind of learning contributes not only to individual abilities or skills, but especially to the capacity of the community as a whole to perform certain actions, connecting to the notion of "community capacity building" [7], especially popular in the discourse on governance.

Collaborative learning alignment in the social learning context expands on the considerations that the previous section accounted for regarding individual learning. Figure 8 indicates how we can use the proposed participant knowledge profile to address how participant profiles overlap and how the values and perspectives of participants align, while specialised learning occurs. Notably, the diagram also suggests that the specialised learning of one participant can trigger other participants to follow in obtaining knowledge in the same or related areas of expertise.

Fig. 8. Juxtaposition of participant profiles indicates the coexistence of two distinct types of collective learning, namely collaborative learning alignment and specialisation, both of which are catalysed by joint prototyping activities.

5.3 Prototyping perspective

Having gained a better understanding of individual learning and community capacity building happening in civic hackathons, the third perspective that we take focuses on the hacking of a prototype as an activity that differentiates a civic hackathon from other peer learning activities. What appeared significant is the role played by prototypes and other forms of intermediate design representations. We have observed that talking about the application of individual skills to an app, service or product gave participants a way to both align their general views on addressed problems and to position their individual skills in the context of what would need to be done to bring such an app, service or product into being. This supports the role that Carlile [4] gives to prototypes and design representations as boundary objects "representing, learning about, and transforming knowledge to resolve the consequences that exist at a given [community] boundary".

Articulating this role of prototypes in the learning process during civic hackathons has given us ground to extend our enquiry into the way in which prototyping tools introduced to participants support or inhibit the prototype's boundary object role. For example, a code snippet written by one of the participants extracting and processing data from one of the data repositories was a specialised, and functionally useful, ingredient of a potential app. However, in and of itself, it had a very limited role in communicating to other hackathon participants about the merits of the problem being addressed. Conversely, for example, a "paper prototype" jointly developed by participants could be easily understood by all of them on the conceptual level and supported discussion and team alignment. As illustrated in Figure 9, both such types of prototypes can be related to the different types of learning that we have previously identified. "Conceptual prototypes" overlap with team alignment, while "specialised prototypes" support specialised skill learning.

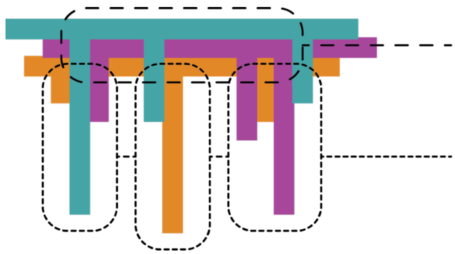

Fig. 9. Specialised prototypes and conceptual prototypes played distinct roles in the learning process during civic hackathons, as they respectively facilitated specialised learning and the team alignment of participants.

The proposed distinction of prototypes raises numerous new questions regarding process organisation and the facilitation of civic hackathons. Different forms of process facilitation, and various selections of prototyping and design tools provided to participants in the civic hackathon can effectively guide the learning process towards either alignment of participants or specialisation in given knowledge areas.

4.4 Facilitation perspective

The organisation of the O4C civic hackathon pilots was inspired by the inspire-ideate-implement approach of IDEO [3]. Considering our findings regarding the different forms of learning and different roles that prototypes played in this process, we can attempt to gain additional understanding of how participants' learning process is affected by the organisational context of civic hackathons, and how this context can be expanded beyond the physical and temporal scale of the hackathon event. In this investigation, Von Hippel's concept of "sticky information" [31] sheds particular light on the role of context and locality in learning-by-making communities. It also draws attention to the notion of a community of practice [10][32] that hackathon participants are stimulated to form, within, and beyond the hackathon event. Those perspectives provide us with a rich framing for the capacity building process occurring in the civic hackathons, where individuals' learning processes align in respect to one another, around the prototype and within the nested loci of the hackathon event and the city in which the hackathon team operates.

The above theoretical framing brings two facilitation problems to the foreground, which open further areas of enquiry for the next stages of our research. First is the question of the role of data prototyping tools. These tools need to accommodate both the specialised and conceptual role and, in this, may be used throughout the stages of the entire process, not exclusively in the final implementation stage. Second is the question of sustaining the capacity building locus beyond what the hackathon temporarily provides.

The civic hackathon processes we have facilitated had an apparently linear structure. They started with pre-hackathon preparations, proceeded through inspire, ideate, implement stages during a hackathon and were followed with post-hackathon activities aiming to follow up on designed and prototyped ideas. Taking the learning perspective on understanding this process gives us a framing that allows us to conceptually expand our understanding of the learning process beyond the spatio-temporal scale of a single event. The above consideration can be translated to a three-step framework for facilitation of civic hackathons as a means to support smart learning ecosystems in smart cities, illustrated in Figure 10. The three steps correspond to the three discussed perspectives for understanding learning in civic hackathons. Individual learning, community capacity building and generation of prototypes are, consequently, three different aspects of civic hackathons that have different key performance and key behaviour indicators, yet are all essential ingredients of a civic hackathon event. Performed together, they constitute a positive learning loop, where individuals' skills contribute to the capacity of the community, lead to applications of these skills in a complementary fashion to prototypes, and enable individuals to learn from these prototypes.

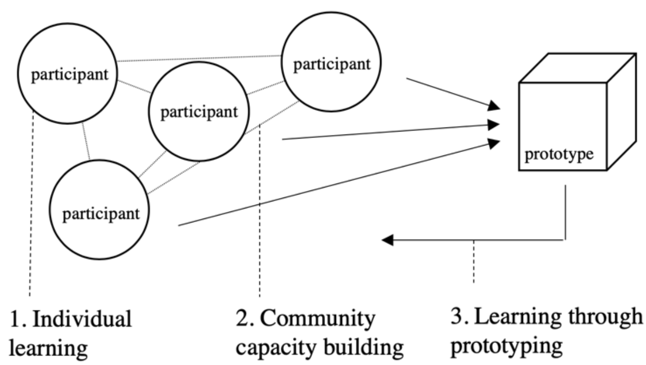

Fig. 10. Individual learning, community capacity, and learning through prototyping are three different aspects of civic hackathons that have different key performance and key behaviour indicators, yet are all essential ingredients of a successful civic hackathon event.

5. Conclusions

Research presented in this paper has explored the opportunities of leveraging civic hackathon events as catalysts for learning in citizen communities. The aim behind the five civic hackathon cases involved in our research has been to improve citizens' capacity to use open data and to enable citizens to participate in the process of developing open data applications. It was our key assumption that "making with data" by jointly designing and prototyping apps, services or products during a pressure-cooker civic hackathon event creates conditions in which citizens develop data literacy and apply it for the common good. Performing and analysing five civic hackathon processes has given us an opportunity to confirm this assumption. It has also expanded our understanding of how such learning processes happen and how they can be supported. In evaluating collected data, we have reached out to theories originating from a variety of disciplines, providing us with a cross-disciplinary perspective on the civic hackathon learning phenomenon, its challenges and opportunities.

In our findings we have identified and scrutinised four perspectives of the civic hackathon learning processes, namely, a) individual learning, b) community capacity building, c) learning through prototyping and d) process facilitation. Across these perspectives, a view of citizens as individuals with a unique composition of prior skills and knowledge prevailed. Next to our initial goal of supporting these citizens in obtaining data-related expertise, we recognised the relevance of their different skills and abilities for the development of valuable open data applications. During the civic hackathons, we have observed the alignment of involved citizens' values and motivations, including learning about each other's viewpoints and expertises, and developing shared visions, as an essential component of their learning process. In fact, without a shared understanding among hackathon team members of the merit of other participants' viewpoints, skills and knowledge, successful collaborative work on applying open data to solving complex social challenges would have been very difficult. In keeping with van Waart et al. [30], we found the value of participatory prototyping in strengthening such shared understanding among the local citizen activist networks. Joint prototyping allowed participants to make their own specific expertise and its usefulness for the job at hand explicit to themselves and to other team members. This encouraged both individual and social learning during civic hackathon events. It also formed bonds and shared goals among participants to continue their joint activities beyond the hackathon event.

The collected insights have brought us to a general framework defining individual learning, community capacity, and learning through prototyping as three mutually enforcing learning activities in civic hackathons. This framework promises to serve as a guideline for defining appropriate key performance and behavioral indicators for assessing learning in future civic hackathons. We also hope this framework will be of use to civic hackathon facilitators, by emphasizing the relevance of capacity building, individual learning, and the knowledge-generating role of prototypes.

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