What the Hack? – Towards a Taxonomy of Hackathons

Christoph Kollwitz(✉) and Barbara Dinter

Chemnitz University of Technology, 09126 Chemnitz, Germany
{christoph.kollwitz,
barbara.dinter}@wirtschaft.tu-chemnitz.de

Abstract. In order to master the digital transformation and to survive in global competition, companies face the challenge of improving transformation processes, such as innovation processes. However, the design of these processes poses a challenge, as the related knowledge is still largely in its infancy. A popular trend since the mid-2000s are collaborative development events, so-called hackathons, where people with different professional backgrounds work collaboratively on development projects for a defined period. While hackathons are a widespread phenomenon in practice and many field reports and individual observations exist, there is still a lack of holistic and structured representations of the new phenomenon in literature. The paper at hand aims to develop a taxonomy of hackathons in order to illustrate their nature and underlying characteristics. For this purpose, a systematic literature review is combined with existing taxonomies or taxonomy-like artifacts (e.g. morphological boxes, typologies) from similar research areas in an iterative taxonomy development process. The results contribute to an improved understanding of the phenomenon hackathon and allow the more effective use of hackathons as a new tool in organizational innovation processes. Furthermore, the taxonomy provides guidance on how to apply hackathons for organizational innovation processes.

Keywords: Hackathon · Taxonomy · Digital innovation · Open innovation · Innovation process

1 Introduction

One of the central tasks of business process management (BPM) is to deal with changing environmental conditions [1]. In recent years, such a transformation appears in trends like shorter product life cycles and increasingly heterogeneous customer requirements. In this context, business processes in the field of innovation management are opening up and changing rapidly, which is addressed by BPM, e.g. by new information sources. Companies invest significant sums in R&D to master the challenges of digital transformation and to survive in the global economy. Traditionally, they have innovated almost solely to prevent leaking knowledge, technologies and process know how to unauthorized third parties or competitors [2]. However, companies merely focusing on internal competencies and resources fall behind in a

T. Hildebrandt et al. (Eds.): BPM 2019, LNCS 11675, pp. 354–369, 2019.
https://doi.org/10.1007/978-3-030-26619-6_23

hardening competition. Therefore, since the beginning of the 21st century a paradigm shift towards opening innovation changes the way how innovation processes are designed and how external knowledge contributes to the development of new products and services. As a bottom line of this so-called open innovation (OI) Chesbrough [3 p. XXIV] states that companies "can and should use external ideas as well as internal ideas, and internal and external paths to market" and over time various approaches for its operationalization have been developed. On the one hand, the advent of Web 2.0 technologies has enabled OI tools like online communities and product platforms for OI, while, on the other hand, the involvement of lead users and other stakeholders in (offline) innovation workshops was highlighted. All these approaches have in common that they understand innovation as the result of collaborative processes in (interdisciplinary) teams rather than as the work of individuals [4]. In addition to the paradigm of OI, digitalization has radically changed the nature of innovation. Digital innovation is in particular shaped by emerging (information) technology and the ubiquitous availability of (digital) data, enabling companies to provide "data-enriched offerings" to their customers [5].

Facing the trends towards openness and digitalization, companies need to find new ways to manage innovation processes in the digital age. More precisely, it poses a challenge for business process management to manage creative processes within and outside organizational boundaries [6], especially when organizations have little or no knowledge about their innovation partners [7]. In this paper, we will therefore investigate a phenomenon in which these two trends are manifested - so-called hackathons. Hackathons can be briefly described as events in which participants collaborate intensively on completing projects over a defined period of time [8]. Such projects focus on an IT-related topic, e.g. developing hardware and/or software, analyzing data sets or identifying IT-security issues. Hackathons can help companies, especially in the early stages of innovation, to generate new ideas, develop concepts or test solutions [9]. Although hackathons are becoming more and more popular in practice, related research is still in the fledgling stage. Thus, existing literature often consists of experience reports, white papers or reflections on specific application domains such as healthcare or smart cities. Companies need help for answering the question of how they can support the application of OI tools [10]. Therefore, they need a holistic view on phenomena like hackathons, which is currently not provided by the literature [11]. This leads us to our research question: How can the complex phenomenon of hackathons be systematically conceptualized in order to enable organizations to utilize them for their innovation processes? In order to answer the research question, we build a taxonomy of hackathons, applying the method for taxonomy development according to Nickerson et al. [12]. A taxonomy is a frequently hierarchical and evolutionary classification of empirical entities that can be used by researchers to organize research fields or entities [13, 14] and is frequently used in the Information Systems (IS) research domain.

The paper is organized as follows: In Sect. 2, we discuss hackathons as a manifestation of OI in more detail and clarify in particular which role they can play in OI processes. Afterwards, our research method is explained in Sect. 3, followed by the presentation of the resulting taxonomy in Sect. 4. The results are discussed in Sect. 5 before we draw a conclusion in Sect. 6.

2 A Process-Centric Perspective on Open Innovation and Hackathons

OI represents a challenge for the management of innovation processes, as it is linked to a shift from well-defined and structured processes to more interactive and agile processes [15]. Uncertainties regarding the results, process structures and required resources prevail within creativity-intensive process stages [16], which are particularly important at the beginning of the innovation process. Many different approaches to conceptualize innovation at the process level can be found in the literature (for an overview cf. [17]). In this paper, we follow Hansen and Birkinshaw [18], who make a simple distinction between: (1) idea generation, (2) idea conversion and (3) idea diffusion. Thereby, the innovation process is often described as a "funnel", since at the early stages there are many opportunities for innovation, of which only a few are concretized and realized at the later stages [19]. Based on this basic process model, innovation processes can be opened for different purposes for external knowledge. Gassmann and Enkel [20] distinguish three types of OI: (1) outside-in OI describes the sourcing and acquisition of expertise and ideas for the innovation process, while (2) inside-out OI focuses on the exploitation of ideas and the results of innovation processes. If outside-in and inside-out processes are combined, it is referred to as (3) coupled OI. The different types are in turn associated with different tasks. The outside-in perspective of OI comprises the identification, procurement and integration of innovations as well as the interaction with external partners [21]. The inside-out process, which receives less attention compared to the first perspective in the literature, can in turn be subdivided into the search for technology users and the commercialization phase [10]. In order to operationalize these processes, many different means are discussed in research. Battistella et al. [22] identify a total of 23 practices which were used by companies to implement out-side (e.g. crowdsourcing), inside-out (e.g. out-licensing of intellectual property) or coupled OI (e.g. joint ventures). With a focus on Web 2.0 technologies, Möslein and Bansemir [23] distinguish between innovation contests, innovation markets, innovation communities, innovation toolkits and innovation technologies as OI tool categories. Additionally, various authors emphasize the involvement of stakeholders such as customers/users through innovation workshop [24].

In this context, hackathons are considered as an OI tool, which can hardly be classified into existing tool categories since it combines elements of different tool classes. The term hackathon is a portmanteau from "hack" and "marathon" and was first coined at an OpenBSD developer event in Calgary in 1999. There is a variety of synonyms or similar terms such as hack day or hackfest, however, hackathon is by far the most popular term. Furthermore, hackathons that focus on the collection, analysis and/or visualization of data are also referred to as "datathons". Hackathons are rooted in the open source movement and have often been associated with civic engagement and open data [25]. Thus, there are initiatives from government agencies, which aim to increase the participation of citizens and to foster government transparency [26]. Other hosts of hackathons are organizations from the non-profit sector, such as educational institutions or research institutes or NGOs, which address social problems like environmental protection or poverty reduction [27]. However, since large digital players such as Google and Facebook have regularly conducted hackathons in which also external developers have participated [28], they have become a more and more interesting topic for companies of all industries who aim to complement traditional organizational innovation processes. Although there is a high variance in the activities and routines that take place during hackathons, three phases can be roughly distinguished [11]. In the (1) pre-hackathon phase, the focus lies on planning and design tasks. Besides, team building and initial idea generation can also start in this phase. Subsequently, the (2) hackathon phase includes the execution of the event, i.e. the collaborative work of the participants. In the (3) post-hackathon phase, the decision must be made whether and how the results of the hackathon should be followed up (by the host organization or the participants) or should be dropped. Hackathons aim to harness external knowledge for organizations, which corresponds with the outside-in type of OI. The knowledge is integrated mainly in the phases of idea generation and idea conversion and thus serves the organization primarily for knowledge exploration. However, hackathons can also be used in the later innovation process and enhance the diffusion of innovations [9].

3 Research Approach

3.1 Taxonomy Development

As mentioned in the introduction, our research is motivated by the emerging phenomenon of hackathons - in particular, by the discrepancy between the large number of anecdotal observations and field reports on the one hand and the lack of a holistic and comprehensive view on hackathons on the other hand. We would like to emphasize that there are many (scientific) publications on hackathons, which are also shown by the results of our literature search. However, these describe single instances or potential applications in specific areas and do not provide a consolidated and comprehensive view of the phenomenon. Taxonomies are particularly suitable for structuring and classifying complex research topics and therefore play an important role in various areas of IS research [29]. Especially with regard to emerging digital technologies or the management of novel (open) processes, taxonomies can help to consolidate knowledge and make it usable for practitioners as well as for researchers [30, 31]. For the development of the taxonomy we apply the established method of Nickerson et al. [12], which is guided by best practices from other research disciplines as well as the principles of Design Science Research [e.g. 32].

The first step in taxonomy development is the definition of a (1) meta characteristic, which is intended to support researchers to identify meaningful categories and dimensions that relate to the purpose of the taxonomy. In our case, the taxonomy is supposed to support the integration of hackathons into organizational innovation processes. Therefore, we examine hackathons from an organizational perspective and focus on dimensions and characteristics that cover the broad spectrum of design decisions associated with the design and execution of hackathons. The second step of Nickerson's method involves the determination of objective and subjective (2) ending conditions. Objective ending conditions are achieved when all objects of a population or a statistical sample have been analyzed and the result meets the requirements of a taxonomy (e.g. no redundancies/duplications, mutual exclusivity) [12]. Subjective ending conditions affect the researchers assessment of the resulting taxonomy and describe to what extent the taxonomy is considered to be concise, robust, comprehensive, extendible and explanatory [12]. In the third step, the taxonomy is created. Nickerson suggests an iterative process, which is performed until the previously defined ending conditions are met. In general, this process can be inductive (empirical-to-conceptual) or deductive (conceptual-to-empirical), whereby our approach focuses on the former one. Thus, our taxonomy is mainly based on a systematic literature review, which is described in more detail in Subsect. 3.2. The articles were manually screened and analyzed according to the meta characteristic using open, axial and selective coding [cf. 33]. Three iterations were carried out until the ending conditions were reached:

- Open coding: In the first iteration (empirical-to-conceptual), we examined the articles of the literature base according to the meta characteristic for statements on design, execution and objectives of hackathons and grouped by similar characteristics.
- Axial coding: In the second iteration (conceptual-to-empirical), existing taxonomies or taxonomy-like artifacts (e.g. morphological boxes, typologies) from similar research areas were included [e.g. 34–36] and compared with the attributes identified in the first iteration. In case of similarities, the dimensions and characteristics (partially modified) were included in the taxonomy.
- Selective coding: In the third iteration (empirical-to-conceptual), the characteristics identified in the literature, which could not be assigned to any dimension in the second iteration, were summarized in new dimensions and integrated into the taxonomy. Furthermore, the complete taxonomy was refined based on the objective and subjective ending conditions. In addition, the characteristics and their attributes were checked for correlations and dependencies (cf. Subsect. 4.1).

3.2 Literature Review

In recent years, a growing number of scientific publications in books, journals as well as conference proceedings reflect the increasing complexity of research. In this context, literature reviews can help to consolidate knowledge from different research areas and to gain insights into specific problem areas [37]. We decided to use a systematic literature review for the development of a hackathon taxonomy mainly for two reasons. First, such a meta-analysis allows us to access and investigate a large number of hackathon reports covering a broad spectrum of applications. Second, we can apply established methods for the literature review which facilitate the systematic development of our hackathon taxonomy [38, 39]. Vom Brocke et al. [38] propose a five phase model for literature reviews in IS.

The first step is to define the scope, which can be described using Cooper's literature review taxonomy [37]. Table 1 shows the scope of our literature review. We focus on hackathons described in the literature, whereby analyzing their (A) application and design and only marginally considering the results, the methods and underlying theories presented in the papers. Our goal is to (B) integrate existing knowledge and make it usable, in other words, we aim at a (C) conceptualization of the hackathon phenomenon. Our perspective is (D) neutral to avoid distorting the results of the review. As already mentioned in the introduction, our target (E) audience consists of practitioners on the one hand and general researchers on the other. Our aim is to consider an exhaustive literature basis when developing the taxonomy, whereby we prove the individual dimensions and characteristics of the taxonomy based on selected articles. Therefore, we assign our review in category (F) coverage as exhaustive and selective.

Table 1. Taxonomy of literature reviews [37, 38]

<table>
<tr><th>Characteristics</th><th colspan="12">Categories</th></tr>
<tr><td>(A)Focus</td><td colspan="3">research out-come</td><td colspan="3">research method</td><td colspan="3">theories</td><td colspan="3">applications</td></tr>
<tr><td>(B) Goal</td><td colspan="4">integration</td><td colspan="4">criticism</td><td colspan="4">central issues</td></tr>
<tr><td>(C) Organisation</td><td colspan="4">historical</td><td colspan="4">conceptual</td><td colspan="4">methodological</td></tr>
<tr><td>(D) Perspective</td><td colspan="6">neutral representation</td><td colspan="6">espousal of position</td></tr>
<tr><td>(E) Audience</td><td colspan="3">specialized scholars</td><td colspan="3">general scholars</td><td colspan="3">practitioners / politicans</td><td colspan="3">general pub-lic</td></tr>
<tr><td>(F) Coverage</td><td colspan="3">exhaustive</td><td colspan="3">exhaustive and selective</td><td colspan="3">representa-tive</td><td colspan="3">Central / piv-otal</td></tr>
</table>

The second step includes a broad conceptualization of the research subject, in our case hackathons, for which we would like to refer to Sect. 2. The third step consists of the literature search, which includes the selection of databases and keywords as well as the forward and backward search for literature [38]. Regarding the keywords, we searched for the terms, which are depicted in Table 2. We have deliberately excluded related terms such as "jam", since they are often used in other contexts. Following the recommendations of vom Brocke et al. [38], we first searched the top journals of IS discipline (Senior Scholars' Basket of Journals) for relevant publications. We did not find any relevant hits, which corresponds to our expectation that hackathons have not yet found their way into the most renowned journals. Then we expanded our search to the scientific databases AIS Electronic Library (AISeL), IEEE Xplore Digital Library (IEEE) as well as the citation database "Web of Science Core Selection" (WoS), where we searched in "titles", "abstracts" and "keywords" for the mentioned terms.

Table 2. Database search results by keywords

		Keywords				
		hackathon / hack-a-ton	hack day	datathon	hackfest	codefest
Data-bases	AISeL	4	1	2	0	0
	IEEE	63	2	0	1	0
	WoS	147	6	6	1	1

We received 234 hits in total. After eliminating duplicates, removing irrelevant papers (by checking titles and abstracts) and a forward and backward search, we ended up with 189 publications, which we included in the literature analysis. These publications are mostly conferences proceedings or practice-oriented journal articles. Some of the papers describe hackathons that have taken place in the context of conferences, teaching in higher education or other events. The third step of a literature review according to vom Brocke et al. [38] contains the analysis and synthesis of literature. For this purpose, we followed the approach proposed by Nickerson et al. [12] as explained in Subsect. 3.1. The final step of the literature review framework is the development of a research agenda. Since our main interest is the taxonomy development for hackathons and we do not primarily aim to identify research gaps, we have decided not to derive a research agenda. However, in Sect. 6 we highlight potentials for further research.

4 A Taxonomy of Hackathons

4.1 Overview of the Taxonomy

In the course of the analysis, it became apparent that the dimensions could be assigned to two categories. Strategic design decisions (SDD) tend to be abstract in character and are derived from the overall goals and business model of organizations, while operational design decisions (ODD) mainly determine the workflow and processes that take place during a hackathon. With regard to the benefits of the taxonomy for organizations, these categories serve different purposes. The SDD support the organization in identifying useful application scenarios for hackathons. They outline the options in terms of which challenges could be addressed for which purposes. The ODD can in turn support organizations in designing specific settings that fit their organizational environment. For example, different dimensions can be adjusted according to the financial, human and spatial resources of an organization. Some SDD dimensions partly have an influence on ODD or determine them. Table 3 gives an overview of our taxonomy of hackathons, while we present the dimensions and characteristics in the Subsects. 4.2 and 4.3.

Table 3. Taxonomy of hackathons

<table>
<tr><th></th><th>Dimension</th><th colspan="12">Characteristics</th></tr>
<tr><td rowspan="4">SDD</td><td>OI integration</td><td colspan="4">idea generation</td><td colspan="4">idea conversion</td><td colspan="4">idea diffusion</td></tr>
<tr><td>Challenge design</td><td colspan="4">technology-centric (API, software, hardware)</td><td colspan="4">topic-centric (social issue, business problem)</td><td colspan="4">data-centric (analysis, visualization, gathering)</td></tr>
<tr><td>Solution space</td><td colspan="4">open</td><td colspan="4">semi-structured</td><td colspan="4">structured</td></tr>
<tr><td>Value proposition</td><td colspan="6">focus on challenge output</td><td colspan="6">focus on human interaction</td></tr>
<tr><td rowspan="6">ODD</td><td>Duration</td><td colspan="4">short (<24 h)</td><td colspan="4">medium (>24h – 72h)</td><td colspan="4">long (>72h)</td></tr>
<tr><td>Degree of elaboration</td><td colspan="3">ideas and broad concepts</td><td colspan="3">conceptual solutions</td><td colspan="3">functional solutions</td><td colspan="3">finished products / services</td></tr>
<tr><td>Venue</td><td colspan="4">physical</td><td colspan="4">virtual</td><td colspan="4">combined</td></tr>
<tr><td>Incentives</td><td colspan="6">competition</td><td colspan="6">collaboration</td></tr>
<tr><td>Target audience</td><td colspan="4">domain experts</td><td colspan="4">(semi-) professionals</td><td colspan="4">general public</td></tr>
<tr><td>Resources</td><td colspan="4">provided</td><td colspan="4">partially provided</td><td colspan="4">not provided</td></tr>
</table>

4.2 Strategic Design Decisions

OI Integration. As already mentioned in Sect. 2, hackathons can be considered as OI tools that are typically applied to the outside-in process. In general, they can be applied in all phases of the innovation process [18], with different objectives being pursued. In the *idea generation* phase, hackathons aim to generate initial innovation impulses from the outside. With regard to the *idea conversion*, promising ideas are to be selected for further development in cooperation with external developers. The phase *idea diffusion* involves testing and presenting products and services that have already been available on the market [9]. For example, software can be provided in order to deduce room for improvement or possible applications from hackathon results. This dimension is of particular importance since it constitutes the interface between OI process management and hackathon design.

Challenge Design. A common characteristic of all investigated hackathons is that they are associated with the handling of a task or the solution of a problem. This dimension represents the focus of the hackathon's task or challenge. The primal form of hackathons, originated in the open source movement, was strongly oriented towards specific *technology* issues, including software, hardware or APIs related tasks [11]. Hackathon challenges can also pursue social or business *topics*, which does not mean that technology does not play a role, rather their purpose is focused on solving a problem by using technologies [27]. In addition to these two characteristics, which are similarly proposed by Briscoe and Mulligan [25], we add *data-centric* as a third characteristic. Thus, the general trend towards “big data” means that challenges aim at generating value from data without having a dedicated technology or a specific business case in mind [40]. Such tasks focus on the processing, analysis or visualization of data sets [41], and in some cases on the collection or generation of data [42].

Solution Space. This dimension refers to specifications made with regard to the execution of the hackathon. We distinguish between *open*, *semi-structured* and *structured* settings. Open settings are characterized by wide-ranging challenges that leave plenty room for interpretation and own ideas. Requirements and restrictions that could potentially limit creativity are reduced to a minimum. The SPIE Software Hack Day 2014 [43] offers a vivid example of such an open solution space. Participants were invited to “collaborate on innovative solutions to problems of their choice” [43]. The format took place without prior registration, a fixed schedule or formal presentations. Semi-structured settings on the one hand provide certain specifications that limit the solution space, but on the other hand leave room for individual approaches [44]. Either the procedure can be limited by the specification of e.g. technologies, data sets or methods that have to be used [45]; or the expected results are specified by technical and/or functional requirements [46]. Structured settings in turn place strict demands on the procedure and the results, which severely limits the solution space. For example, the JUCE Machine Learning Hackathon [47] was an event in which the technology to be used (a C++ framework focusing on audio applications) as well as the type of solution (application of machine learning) were specified.

Value Proposition. This dimension takes into account that hackathons are not autotelic, but are organized for specific purposes. In reality, there are overlaps, as organizations are likely to pursue different objectives simultaneously. This is contradictory to the principle that the characteristics of a taxonomy should be mutually exclusive [12]. However, we consider this dimension to be important, thus we assume that organizations, even if they pursue different goals, associate a primary value proposition with a hackathon. In our analysis, two primary value propositions with different focuses emerged. On the one hand, value propositions with a *focus on challenge output* aim to harness the results of the participative work in the hackathon. Usually this involves results developed in the hackathon such as ideas, models, prototypes or data visualizations as well as extension, improvement or evaluation of existing entities (e.g. extension of software functionalities or detection of security breaches) [25]. On the other hand, value propositions with a *focus on human interaction* aim to generate benefits with respect to the participants. This includes educational aspects as well as the recruitment of new employees [41]. Furthermore, hackathons can be utilized as a communication platform for stakeholders and marketing purposes [11]. In any case, it is important for organizations to be aware of their own expectations and to establish measures for making the results connectable in their own organization.

4.3 Operational Design Decisions

Duration. Hackathons are events that take place over a short period of time, whereby the concrete timing varies greatly in practice. On one side of the continuum, there are hackathons with *short* duration that last only a few hours as a one-day event, which is particularly likely when they are part of other events (e.g. scientific conferences). Lau and Lei [48], who describe a 30-min hackathon at the "International Microwave Symposium 2017", provide a demonstrative but extreme example of this characteristic. The vast majority of the hackathons discussed in the literature lasted between 24 and 72 h, which we refer to as the *medium* period of time [9]. On the other side of the continuum, there exist *long* duration hackathons that can last from four days up to several weeks [49]. Hackathons with long duration are usually not continuous but consist of multiple events (e.g. kick-off and award ceremony) linked by an intervening development period.

Venue. Hackathons not only deal with technology-related topics. Information technology can also act as a medium for communication and cooperation during the events. While "classic" hackathons take place at *physical* locations [44], there are also formats that are completely organized *virtually* via online platforms or social networks (e.g. Kaggle) and therefore do not require physical presence [42]. Additionally there is the possibility to *combine* physical and virtual venues [49]. Concerning the physical venues, the analyzed articles describe frequently the importance of open and innovation-friendly spaces equipped with tools for collaboration and ideation (e.g. flipcharts or brown paper). Choosing a physical venue also means limiting capacity, while virtual venues allow a literally unlimited number of participants.

Degree of Elaboration. Hackathons are aimed at dealing with technology related issues, but differ greatly in terms of the intended results. We have decided to cluster the different characteristics according to the degree of elaboration, as there is an unlimited variety of resulting artifacts in practice. Artifacts with a relatively low degree of elaboration require only a basic understanding of technologies and operate at a high level of abstraction. The focus is on creativity and the development of *ideas and broad concepts* [50]. A higher degree of elaboration requires a further development of ideas and to *conceptual solutions*. These conceptual prototypes are usually demonstrative paper-based or computer-aided mock-ups that represent a concept resulting from a hackathons, but do not contain any functionalities [51]. The next higher degree of elaboration is obtained when functionalities of the solution are also implemented. Such *functional solutions* include core functions of an e.g. prototype and thus demonstrate the general feasibility of a concept (proof of concept) [8]. The highest degree of elaboration is reached when the hackathon results in *finished products/services*, which are at least mature enough to be launched (minimal viable product) [52]. As the degree of elaboration increases, the demands of the technical and professional skills of the participants usually also increase, while creativity and the ability of abstraction become less important.

Incentives. In general, hackathons are team events, whereby the type of team composition (e.g. before or during the event) and the team sizes can vary. Although hackathons generally emphasize the value of cooperation, they can be designed as *competitions* in which participants compete among each other. Based on a jury decision, audience vote or self-assessment, the winners usually receive a prize which is intended to increase the extrinsic motivation of the participants [9, 53]. The alternative concept relies entirely on *collaboration* rather than any competition between participants [54].

Target Audience. Although hackathons are traditionally open events, there could be various restrictions concerning the participation. We identified various types of hard restrictions in the literature. For example, in-house hackathons which can only be visited by employees of an organization or hackathons that target socio-demographic characteristics of the participants, such as age, gender or profession [11]. Furthermore, tasks can be chosen in a way that only *domain experts* are able to participate, e.g. physicians [41] or architects [50]. In addition to these hard restrictions, there are soft criteria that are frequently based on the self-assessment of participants. Such constraints often aim to acquire participants with expertise in specific areas such as marketing, programming or data analysis [55]. We refer to this characteristic as *(semi-) professionals*. The last characteristic refers to hackathons, which have no restriction of participation apart from a basic interest in the topic [51], thus, they target the *general public*.

Resources. The last dimension differentiates whether resources are *provided* to the hackathon participants or *not*. Likewise, only some resources can be made available, which we characterize as *partially provided*. In our context, provided resources can be considered as an input, which is made available to the participants before or during the hackathon. The provided resources may be hardware, software or data sets as well as existing ideas, concepts or prototypes, which should be evolved [56]. Furthermore, human resources such as mentors or experts from practice can serve as an input for the participants [57]. Depending on the setting, the usage of resources can be voluntary or mandatory (cf. solution space). The question of whether or not resources will be provided may be related to single SDD dimensions. For example, existing ideas or concepts must be available as input for the participants if a hackathon aim to idea conversion or diffusion.

5 Discussion

OI has been around for several years now and scholars from different professions had already discussed many tools, especially in the context of web 2.0 and social software [26]. Hackathons combine elements of such OI tools with elements from the areas of open source and agile software development [49]. Thus, the dimensions and characteristics of our taxonomy of hackathons is not disconnected from other OI tools and practices, but features several similarities. Hackathons have event character and resemble innovations contests in the dimensions solution space, duration, degree of elaboration, venue and target audience [34]. Furthermore, the dimensions OI integration and solution space correspond to the typology of the customer co-creation by Piller et al. [36]. However, the taxonomy contains dimensions that cannot be found in other classifications and dimensions that have completely different characteristics. For instance, challenge design describes the IT-related aspects of hackathons, while incentives show that hackathons can be both competitive and collaborative. Our taxonomy also shows that hackathons are very diverse in their practical manifestation, which contradicts several restrictive definition approaches from literature on hackathons. Hackathons are frequently characterized as competitive, short-term events in which software is developed [e.g. 9, 25]. Our analysis showed that hackathons could be considered as OI tools with a wide range of applications, rather than being limited to competitions, short periods or software development projects.

Since hackathons must be incorporated into BPM, our taxonomy highlights many dimensions, such as resources or process participants to be considered [1]. Our approach transfers the established method of taxonomy development to the immature field of hackathons and thus, contribute to the knowledge base by exaptation [58]. Since organizations need assistance in managing innovation processes in the age of digitalization [7], our taxonomy of hackathons is intended to enable organizations to utilize hackathons for successful innovating. In this context, where serval uncertainties exist a central challenge poses the management of creativity-intense processes [6]. Our taxonomy can support organizations in planning creative processes in hackathons by constraining them, which in turn helps to manage uncertainties regarding (1) results, (2) processes and (3) resources [59]. Concerning the uncertainties of the (1) results, organizations can make detailed specifications regarding the solution space as well as the degree of elaboration in order to channel the creativity of the participants in a desired direction. In addition, uncertainties are generally more pronounced in the early stages of the innovation process than in the later ones, which is reflected by the dimension OI integration. The dimensions challenge design and the solution space have an influence on the (2) process uncertainties, which determine the form and substance of a hackathon. As mentioned above in Subsect. 4.1, all ODD dimensions also have a direct influence on the hackathon processes and their degree of uncertainty. For example, hackathons that have a short duration and take place at a physical location might be easier to predetermine beforehand than those that take place over long periods and include both physical and virtual forms of collaboration. In terms of (3) resource uncertainties, organizations can regulate e.g. the duration and, can provide resources for the participants. In addition, the availability of intangible resources such as expertise or skills can be influenced by the appropriate selection of a target audience.

Another aspect to be discussed is the categorization of SDD and ODD in our taxonomy of hackathons. We consider this a first step to gain a better understanding of how the strategic goals of organizations are linked to the design of hackathon processes. The taxonomy shows application scenarios (SDD) and operational design options (ODD), which can lead to a better strategic alignment, which is considered as a core element of BPM [60]. However, in this article our research approach focused on the design of the taxonomy rather than on the investigation of linkages between strategic and operational elements. In Sect. 6 we will discuss how we intend to achieve this in the future.

6 Conclusion

In this paper, we examine hackathons as a novel phenomenon at the crossroads of digital innovation and OI. We used the method of Nickerson et al. [12] combined with a systematic literature review to develop a taxonomy of hackathon. The result contributes to a better understanding of the opportunities and characteristics of hackathons and is therefore a first step towards a better integration of hackathons into organizational innovation processes. Our results not only give directions which kind of innovation challenges can be addressed, but also provide companies with initial recommendations on how to proceed when using this new resource in the BPM context. From a research perspective, the results contributes by expanding the knowledge base in the spectrum of OI tools and practices as well as in the field of collaborative work in the digital age.

The taxonomy can be considered as generally valid since it was derived from a comprehensive number of primary sources. However, our research is still in an early stage and some limitations exist. The taxonomy is currently based only on findings we have derived from a retrospective review of the literature. Thus, the significance of our results is limited due to the restrictions in the review strategy (restriction to certain databases and keywords). Although we have figured out which dimensions and objectives are discussed in the literature, we need further evidence to show that those aspects are actually relevant from a practical point of view. We aim to compensate for this shortcoming by conducting case studies and in-depth interviews examining the roles of the different actors in real-world hackathons in more detail. In this direction, our next step for further research is to study the relationships between individual dimensions or characteristics. In particular, we want to show the interplay of SDD and ODD dimensions in more detail and further develop the taxonomy into an ontology.

References

1. Smith, H., Fingar, P.: Business Process Management: The Third Wave. Meghan-Kiffer Press, Tampa (2003)
2. Chesbrough, H.W., Appleyard, M.M.: Open innovation and strategy. Calif. Manag. Rev. **50**, 57–76 (2007)
3. Chesbrough, H.W.: Open Innovation: The New Imperative for Creating and Profiting from Technology (2003)
4. Steen, M., Manschot, M., De Koning, N.: Benefits of co-design in service design projects marc. Int. J. Des. **5**, 53–60 (2011)
5. Davenport, T.H.: Analytics 3.0. Harv. Bus. Rev. **12**, 65–72 (2013)
6. Schmiedel, T., vom Brocke, J.: Business process management: potentials and challenges of driving innovation. In: vom Brocke, J., Schmiedel, T. (eds.) BPM - Driving Innovation in a Digital World. MP, pp. 3–15. Springer, Cham (2015)
7. Nambisan, S., Lyytinen, K., Majchrzak, A., Song, M.: Digital innovation management: reinventing innovation management research in a digital world. MIS Q. **41**, 223–238 (2017)
8. Pe-Than, E.P.P., Nolte, A., Filippova, A., Bird, C., Scallen, S., Herbsleb, J.D.: Designing corporate hackathons with a purpose: the future of software development. IEEE Softw. **36**, 15–22 (2019)

9. Rosell, B., Kumar, S., Shepherd, J.: Unleashing innovation through internal hackathons. In: Digest of Technical Papers - InnoTek 2014: 2014 IEEE Innovations in Technology Conference (2014)
10. Aloini, D., Lazzarotti, V., Manzini, R., Pellegrini, L.: Implementing open innovation: technological, organizational and managerial tools. Bus. Process Manag. J. **23**, 1086–1093 (2017)
11. Komssi, M., Pichlis, D., Raatikainen, M., Kindstrom, K., Jarvinen, J.: What are hackathons for? IEEE Softw. **32**, 60–67 (2015)
12. Nickerson, R.C., Varshney, U., Muntermann, J.: A method for taxonomy development and its application in information systems. Eur. J. Inf. Syst. **22**, 336–359 (2013)
13. Bailey, K.D.: Typologies and Taxonomies an Introduction to Classification Techniques. Sage Publications, Thousand Oaks (1994)
14. Glass, R.L., Vessey, I.: Contemporary application-domain taxonomies. IEEE Softw. **12**, 63–76 (1995)
15. Gassmann, O., Enkel, E., Chesbrough, H.: The future of open innovation. R D Manag. **40**, 213–221 (2010)
16. Seidel, S.: Toward a theory of managing creativity-intensive processes: a creative industries study. Inf. Syst. E-bus. Manag. **9**, 407–446 (2011)
17. Eveleens, C.: Innovation management; a literature review of innovation process models and their implications (2010). http://www.academia.edu/download/33190893/Innovation-management-literature-review-.pdf
18. Hansen, M.T., Birkinshaw, J.: The innovation value chain. Harv. Bus. Rev. **85** (2007)
19. Lazzarotti, V., Manzini, R.: Different modes of open innovation: a theoretical framework and an empirical study. Int. J. Innov. Manag. **13**, 615–636 (2009)
20. Gassmann, O., Enkel, E.: Towards a theory of open innovation: three core process archetypes. In: Proceedings of the R&D Management Conference (RADMA), Lisbon, Portugal (2004)
21. West, J., Bogers, M.: Leveraging external sources of innovation: a review of research on open innovation. J. Prod. Innov. Manag. **31**, 814–831 (2014)
22. Battistella, C., De Toni, A.F., Pessot, E.: Practising open innovation: a framework of reference. Bus. Process Manag. J. **23**, 1311–1336 (2017)
23. Möslein, K.M., Bansemir, B.: Strategic open innovation: basics, actors, tools and tensions. In: Michael, H., Pfeffermann, N. (eds.) Strategies and Communications for Innovations: An Integrative Management View for Companies and Networks, pp. 11–23. Springer, Berlin (2011)
24. Edvardsson, B., Kristensson, P., Magnusson, P., Sundström, E.: Customer integration within service development - a review of methods and an analysis of insitu and exsitu contributions. Technovation. **32**, 419–429 (2012)
25. Briscoe, G., Mulligan, C.: Digital innovation: the hackathon phenomenon (2014)
26. Robinson, P.J., Johnson, P.A.: Civic hackathons: new terrain for local government-citizen interaction? Urban Plan. **1**, 65–74 (2016)
27. Ciaghi, A., et al.: Hacking for Southern Africa: collaborative development of hyperlocal services for marginalised communities. In: 2016 IST-Africa Conference, IST-Africa 2016 (2016)
28. Choi, M.: Organizing open digital innovation: evidence from hackathons. In: International Conference on Information Systems (ICIS), Dublin, Ireland, pp. 1–11 (2016)
29. Nickerson, R.C., Varshney, U., Muntermann, J., Isaac, H.: Taxonomy development in information systems: developing a taxonomy of mobile applications. In: Proceedings of the European Conference on Information Systems (ECIS), Verona, Italy, p. 388 (2009)

30. Geiger, D., Seedorf, S., Schulze, T., Nickerson, R., Schader, M.: Managing the crowd: towards a taxanomy of crowdsourcing processes. In: AMCIS 2011 Proceedings (2011)
31. Berger, S., Denner, M.-S., Röglinger, M.: The nature of digital technologies – development of a mulit-layer taxonomy. In: 26th European Conference on Information Systems (ECIS 2018), pp. 1–18 (2018)
32. Hevner, A.R., March, S.T., Park, J., Ram, S.: Design science in information systems research. MIS Q. **28**, 75–105 (2004)
33. Wolfswinkel, J.F., Furtmueller, E., Wilderom, C.P.M.: Using grounded theory as a method for rigorously reviewing literature. Eur. J. Inf. Syst. **22**, 45–55 (2013)
34. Bullinger, A.C., Möslein, K.: Innovation contests – where are we? In: AMCIS 2010 Proceedings, pp. 1–9 (2010)
35. Dinter, B., Kollwitz, C., Fritzsche, A.: Teaching data driven innovation – facing a challenge for higher education. In: AMCIS 2017 - America's Conference on Information Systems: A Tradition of Innovation (2017)
36. Piller, F.T., Ihl, C., Vossen, A.: A typology of customer co-creation in the innovation process. In: New Forms of Collaborative Innovation and Production on the Internet: An Interdisciplinary Perspective. Universitätsverlag Göttingen, Göttingen (2011)
37. Cooper, H.M.: Organizing knowledge syntheses: a taxonomy of literature reviews. Knowl. Soc. **1**, 104–126 (1988)
38. vom Brocke, J., Simons, A., Niehaves, B., Reimer, K., Plattfaut, R., Cleven, A.: Reconstructing the giant: on the importance of rigour in documenting the literature search process. In: Proceedings of the European Conference on Information Systems (EICS 2009), Verona, p. 161 (2009)
39. Webster, J., Watson, R.T.: Analyzing the past to prepare for the future: writing a literature review. MIS Q. **26**, 13–23 (2002)
40. Vanauer, M., Bohle, C., Hellingrath, B.: Guiding the introduction of big data in organizations: a methodology with business- and data-driven ideation and enterprise architecture management-based implementation. In: Proceedings of the Annual Hawaii International Conference on System Sciences (HICSS), Kauai, pp. 908–917 (2015)
41. Wyngaard, J., Lynch, H., Nabrzyski, J., Pope, A., Jha, S.: Hacking at the divide between polar science and HPC: using hackathons as training tools. In: Proceedings - 2017 IEEE 31st International Parallel and Distributed Processing Symposium Workshops, IPDPSW 2017, pp. 352–359 (2017)
42. Alba, M., Avalos, M., Guzmán, C., Larios, V.M.: Synergy between smart cities' hackathons and living labs as a vehicle for accelerating tangible innovations on cities. In: IEEE 2nd International Smart Cities Conference: Improving the Citizens Quality of Life, ISC2 2016 - Proceedings (2016)
43. Kendrew, S., Deen, C., Radziwill, N., Crawford, S., Gilbert, J.: The first SPIE software hack day. In: Proceedings of SPIE, Montreal (2014)
44. Saravi, S., et al.: A systems engineering hackathon - a methodology involving multiple stakeholders to progress conceptual design of a complex engineered product. IEEE Access **6**, 38399–38410 (2018)
45. Charvat, K., Bye, B.L., Mildorf, T., Berre, A.-J., Jedlicka, K.: Open data, VGI and citizen observatories INSPIRE hackathon. Int. J. Spat. Data Infrastruct. Res. **13**, 109–130 (2018)
46. Pathanasethpong, A., et al.: Tackling regional public health issues using mobile health technology: event report of an mHealth hackathon in Thailand. JMIR mHealth uHealth **5**, e155 (2017)
47. Bernardo, F., Grierson, M., Fiebrink, R.: User-centred design actions for lightweight evaluation of an interactive machine learning toolkit. J. Sci. Technol. Arts. **10**, 25–38 (2018)

48. Lau, K., Lei, B.J.: IMS2017 hackathon: 30-minute circuits. IEEE Microw. Mag. **18**, 84 (2017)
49. Ahalt, S., et al.: Water science software institute: agile and open source scientific software development. Comput. Sci. Eng. **16**, 18–26 (2014)
50. Thomas, R.S.: Using design slam to foster lifelong learning solutions. Comput. (Long Beach Calif.) **50**, 32–33 (2017)
51. Concilio, G., Molinari, F., Morelli, N.: Empowering citizens with open data by urban hackathons. In: Proceedings of the 7th International Conference for e-Democracy and Open Government, CeDEM 2017, pp. 125–134 (2017)
52. Avalos, M., Larios, V.M., Salazar, P., Maciel, R.: Hackathons, semesterathons, and summerathons as vehicles to develop smart city local talent that via their innovations promote synergy between industry, academia, government and citizens. In: 2017 International Smart Cities Conference ISC2 2017 (2017)
53. Brenner, W., et al.: User, use & utility research: the digital user as new design perspective in business and information systems engineering. Bus. Inf. Syst. Eng. **6**, 55–61 (2014)
54. Decker, A., Eiselt, K., Voll, K.: Understanding and improving the culture of hackathons: think global hack local. In: Frontiers in Education Conference (2015)
55. Alekseenko, A., Sanchez-medina, J.: Lane departure prediction with naturalistic driving data (2017)
56. Tsukada, M., et al.: Software defined media: virtualization of audio-visual services. In: IEEE International Conference on Communications, pp. 1–7. IEEE (2017)
57. Madelska, S.: News from the field: coders and the creative unite to design and build apps for surface haptics. IEEE Trans. Haptics **8**, 128–129 (2015)
58. Gregor, S., Hevner, A.R.: Positioning and presenting design science research for maximum impact. MIS Q. **37**, 337–355 (2013)
59. Seidel, S., Mueller-Wienbergen, F., Rosemann, M.: Pockets of creativity in business processes. Commun. Assoc. Inf. Syst. **27**, 415–436 (2010)
60. Rosemann, M., vom Brocke, J.: The six core elements of business process management. In: vom Brocke, J., Rosemann, M. (eds.) Handbook on Business Process Management 1. IHIS, pp. 105–122. Springer, Heidelberg (2015)