What do we know about hackathon outcomes and how to support them? – A systematic literature review

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Abstract. Hackathons are time-bounded events where participants gather in teams to develop projects that interest them. Such events have been adopted in various domains to generate innovative solutions, foster learning, build and expand communities and to tackle civic and ecological issues. While research interest has also grown subsequently, most studies focus on singular events in specific domains. A systematic overview of the current state of the art is currently missing. Such an overview is however crucial to further study the hackathon phenomenon, understand its underlying mechanisms and develop support for hackathon organizers, in particular related to the sustainability of hackathon outcomes. This paper fills that gap by reporting on the results of a systematic literature review thus providing an overview of potential hackathon outcomes, design aspects and connections between them that have been addressed in prior work. Our findings also outline gaps in prior work e.g. related to the lack of work focusing on hackathon outcomes other than hackathon projects.

Keywords: Hackathon, Hackathon Design Aspects, Hackathon Outcomes

1 Introduction

Hackathons are time-bounded, themed events where participants with diverse interests, expertise and goals form teams to work on projects that interest them[37]. Starting in the early 2000s, the popularity of hackathons has seen a steep increase in recent years. The largest hackathon league, Major League Hacking (MLH) alone, hosts more than 200 hackathons annually, involving around 65.000 students[1].

The growing popularity of hackathons has subsequently also led to an increased interest in research as evidenced by a large number of publications on the topic. Most research on hackathons, however, currently focuses on studying singular events in specific domains covering aspects such as how to organize a hackathon [37] and how teams self-organize [49]. A systematic overview of the current state of the art about hackathons is missing. Such an overview is crucial as a basis to further study the hackathon

[1]https://mlh.io/about

phenomenon, understand its underlying mechanisms, and develop support for hackathon organizers and participants. Our work aims to address this gap.

In this paper, we particularly focus on the sustainability of hackathon outcomes. As hackathon outcomes, we perceive the diverse direct results of a hackathon, such as prototypes, networking, learning and others [21]. The sustainability of these outcomes has not been studied extensively so far despite organizers and participants investing considerable resources to prepare, run, and follow-up on an event. Previous research even suggests that hackathon outcomes are often not sustained at all [11, 31, 49] rendering the investment of resources useless. In order to develop a systematic understanding of how to sustain hackathon outcomes it is first necessary though to understand which outcomes can be reasonably expected. We thus ask the following research question:

RQ1: What hackathon outcomes have been addressed by previous research?

Understanding which outcomes can reasonably be expected is not sufficient to support their sustainability though. It is also necessary to understand which design aspects form the structure of a hackathon. With design aspects, we refer to characteristics of involved individuals and activities before, during and after a hackathon and that shape the format of a hackathon. This leads to the following research question:

RQ2: What hackathon design aspects have been addressed by previous research?

After developing an understanding of potential hackathon outcomes and aspects that might influence its design, we subsequently focus on previously identified relationships to uncover existing gaps in current research. We thus also ask the following question:

RQ3: Which connections between hackathon design aspects and outcomes have been addressed in prior literature?

In order to answer the aforementioned research questions, we conducted a systematic literature review based on the guidelines described by Kitchenham et al. [27]. Our contribution is twofold: We first provide an overview of potential hackathon outcomes, design aspects and connections between them that have been addressed in prior work. We also outline gaps in prior work e.g. related to the lack of work focusing on hackathon outcomes other than hackathon projects.

2 Background

There is prior work in the hackathon domain where researchers created an overview of different types of hackathons. One example of such works is a typology of hackathons developed by Drouhard et al. [15]. They categorize hackathons in either *communal* (towards community nurturing), *contributive* (issue-oriented), or *catalytic* (towards the search for innovation). A similar approach by Starov et al. [45] also distinguishes hackathons depending on their focus, which could be on innovation, education, or communication. These categorizations are useful to orientate the design of a hackathon towards one focus, but they neither provide an overview of different design aspects nor on how such aspects are connected to the sustainability of the outcomes.

Soltani et al. [44] have discussed connections between different design aspects and hackathon outcomes in the healthcare domain. They identified six hackathon success factors which include the clear definition of the problem area, compensations offered to the winning solutions, and entry requirements for participants, among others. Similarly, Pe-Than et al. [37] elaborate on various design choices connected to strategies, and organizational and personal goals in corporate hackathons. They discuss, for instance, that the continuation of work after a hackathon is linked to the organizational goal of increasing the visibility of projects and the personal goals of gaining recognition and fostering the careers of participants. These two pieces of research work derive their insights from six and ten hackathons respectively which took place in specific domains. Our work, in contrast, aims to provide an overview of previously identified hackathon design aspects and outcomes, as well as connections between them, thus providing a solid basis for future work on the sustainability of hackathon outcomes.

3 Methodology

To answer the research questions stated in the introduction we conducted a systematic literature review based on the guidelines proposed by Kitchenham et al. [27]. Our aim was to create an overview of hackathon outcomes (RQ1), hackathon design aspects (RQ2) and potential connections between them (RQ3). In the following sections, we elaborate on the search queries we used (section 3.1), our inclusion and exclusion criteria (section 3.2), and our process of analysis (section 3.3).

3.1 Search queries

Our search focused on hackathon outcomes (RQ1), we thus used the following main search terms: “hackathon”, “codefest” and “coding competition” as synonyms [8] and combined them with “outcome”. We also included “guide”, “setup”, “design” and “setting”, referring to the design of a hackathon (RQ2). We performed the searches using Boolean operators tailored to the specific search grammar requirements of each library and sorted the results by relevance[2]. We searched for publications from 2010 to 2020 to focus on the most recent work about hackathons We conducted our search using online libraries proposed by Brereton [7]: IEEExplore, ACM Digital library, and Google Scholar, as well as Scopus and Web of Science. After the initial search, we carried out a preliminary screening based on the title, keywords, and abstracts. The search results from ACM were: 80 (74 after preliminary screening), from Google Scholar: 7315 (258 after preliminary screening)[3], from IEEE Xplore Library: 37 (28 after preliminary screening), from Scopus: 259 (102 after preliminary screening) and from Web of Science: 94 (68 after preliminary screening).

[2] We e.g. used the following String for the ACM digital library: +(hackathon) +("outcome" "guide" "setup" "aspect" "design" "setting") +(codefest) +("outcome" "guide" "setup" "aspect" "design" "setting") + ("coding competition") +("outcome" "guide" "setup" "aspect" "design" "setting")

[3] We limited our search to the first 30 results pages.

3.2 Inclusion and exclusion criteria

After screening, we read the remaining papers in detail and applied the following including and exclusion criteria to select the most relevant works:

Inclusion criteria.

Only hackathons. We perceive hackathons as time-bounded, themed events where participants with diverse expertise and goals work in teams on projects that interest them [37] as outlined in the introduction. We only include events that fit this definition. Papers that focus on similar types of events such as workshops or events during which participants work alone, online, or work on a regular project were not included.
Detailed description of the hackathon setup. Papers must include a description of basic hackathon design aspects, such as the number of participants, the agenda, the setup and the main hackathon activities to be included in the analysis.
The hackathon is the main focus. Papers have to focus on studying a hackathon. Papers that focus on hackathons as a means to study other phenomena will not be included.

Exclusion criteria.

Non-peer reviewed work. In order to ensure the quality of the results, we excluded books and book chapters, workshops, theses, institute publications, presentations, posters, monographs, reports, extended abstracts, websites and magazines.
Exploratory work. We excluded papers with less than 5 pages which report on preliminary or exploratory results.

After applying these inclusion/exclusion criteria, the remaining papers (29 journal papers and 61 conference papers) were included in our analysis. Additionally, 1 paper was added from a snowballing process.

3.3 Data analysis

In order to identify potential hackathon outcomes (RQ1) and design aspects (RQ2), the main author of the paper extracted relevant information from the remaining papers and iteratively organized them into categories. The categories were then collaboratively evaluated in a series of iterations together with the second author.

First, we extracted the hackathon outcomes and design aspects mentioned in each paper. We then clustered these aspects based on common outcomes and design aspects between different papers and grouped them into categories (e.g. *"visualizations"* and *"documents"* as outcomes). These clusters subsequently formed larger categories (e.g. *"visualizations"* and *"documents"* were merged into the larger cluster of *"non-technical artifacts"*).

We used a similar procedure to identify connections between hackathon outcomes and design aspects (RQ3). We arranged the connections that were discussed in different papers in a table, outlining the hackathon outcomes on one column and the design aspects on the other (see Table 2 for an overview).

4 Findings

In this section, we will discuss hackathon outcomes (RQ1), design aspects (RQ2), and relationships between them (RQ3) that we identified from our literature review. Section 4.1 focuses on hackathon outcomes (RQ1) and section 4.2 on hackathon design aspects (RQ2). In section 5, we address the current understanding in related work about the relationship between design aspects and the sustainability of outcomes (RQ3)[4].

4.1 Hackathon outcomes (RQ1)

For the purpose of this paper, we differentiate between tangible and intangible hackathon outcomes [46]. Tangible hackathon outcomes include technical and non-technical artifacts, while intangible hackathon outcomes refer to aspects such as learning and networking (see Table 1 for an overview).

Table 1. Overview of identified hackathon outcomes

ID	Hackathon outcomes
	Tangible outcomes
O1	Technical artifacts (e.g. [10, 29, 44])
O2	Non-technical artifacts (e.g. [46, 49])
	Intangible outcomes
O3	Learning (e.g. [10, 21, 29])
O4	Networking (e.g. [10, 21, 29])
O5	Interdisciplinary collaboration(e.g. [10, 47, 49])
O6	Ideas [40, 47]
O7	Entrepreneurship [11, 31]
O8	Fostering existing enterprise [10, 19]
O9	Fostering awareness about hackathon theme [2, 46, 50]

Tangible hackathon outcomes.
These are the most commonly discussed hackathon outcomes. They include technical artifacts such as new prototypes [5, 44, 49], product features [49] and bug fixes [10, 49]. Tangible outcomes may also include non-technical artifacts such as visualizations [40, 43, 49], new or improved documentation [46] and publications [49].

[4] Due to space constraints we only include the most relevant references here. A full list of all references considered in this literature review is available here: https://bit.ly/2CDIezF

Intangible hackathon outcomes.
Intangible hackathon outcomes include participants learning about the main issue of a hackathon [50], new technologies [9, 46], or acquiring industry and in-university skills [33]. Participants can also engage in networking [46] by meeting new people, thus, creating opportunities for collaboration [3, 39]. Both networking and learning can subsequently lead to participants developing new ideas [40, 47]. Other intangible outcomes may include entrepreneurship [11, 31] (i.e. the creation of new startups), fostering existing enterprises [19], and fostering awareness about the theme of a hackathon [2, 50].

4.2 Hackathon design aspects (RQ2)

In this section, we elaborate on design aspects of hackathons that have been discussed in prior work thus answering RQ2 (Fig. 1 provides an overview).

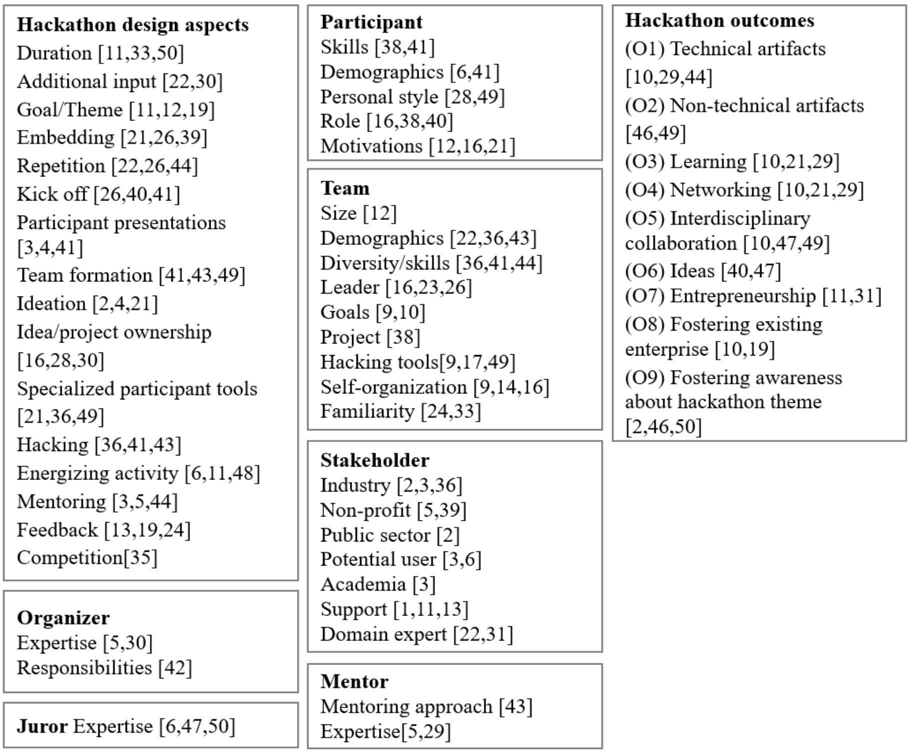

Fig. 1. Overview of identified hackathon design aspects

Hackathons are time-bounded, themed events where participants with diverse interests, expertise, and goals form teams to work on projects that interest them as outlined in the introduction. They can attract diverse **participants** (top-middle in Fig. 1) from different ethnic backgrounds [41], skills [14], education levels [6, 13], and (research) experience [13]. Participants commonly attend hackathons based on individual motivations such as e.g. having fun or learning [40, 50]. Some of them might have previous hackathon experience [29], while others attend a hackathon for the first time. Participants commonly take over a specific role [40] such as team leader, developer, or designer based on prior experience or personal interest.

Participants typically form hackathon **teams** (middle of Fig. 1) which may subsequently consist of participants with different skills [36, 41]. Teams have different sizes that can also fluctuate during the course of a hackathon [14]. Team members can be potential end users of the project they work on during the hackathon [3]. In a team, participants typically agree on the tools [9] they use to work on their project [38] and select a leader [16, 26] for the duration of a hackathon. Some teams form clear objectives and requirements for their project [4, 36] while others choose a less structured approach. Each team's self-organization process can further be influenced by the hackathon venue [36], the size of a team [14], and the guidance they receive [14].

Teams can be supported by **mentors** (bottom in Fig. 1) who help teams achieve their goals by offering advice and directions based on their expertise [5, 29]. For that, different mentors can apply different approaches [43].

A **jury** (bottom-left in Fig. 1) might be formed to evaluate projects at a competitive hackathon. A jury can consist of people with diverse areas of expertise [6, 47, 50] and provide feedback to teams related to their project and choose one or multiple winners.

Stakeholders (middle in Fig. 1) can be involved in hackathons as participants, mentors, jury, or organizers, and can have an active role in the hackathon by being present during the event. They may also contribute by providing financial support [1, 28] typically in exchange for promotional activities.

Hackathon **organizers** (bottom-left in Fig. 1) are in charge of the overall design of a hackathon and use their expertise [5, 30] to design and run them. They have a large array of responsibilities [42] such as marketing an event [6, 17, 48], defining prerequisites for outcomes [42], and recruiting participants [1, 5, 10] based on specific participant selection criteria [5, 10, 22]. They might also provide opportunities for participants to meet prior to the event [13, 17, 26].

Hackathons (top-left in Fig. 1), if organized face-to-face, take place in a venue [21, 36, 41], over a limited period of time [22], with a specific number of participants [20, 41]. A hackathon commonly begins with a kickoff, such as a keynote [41]. Afterwards, participants may can engage in team formation, which could involve different strategies [49]: *open sheepherding*, where participants already come with a project, *selection by organizer*, where teams are formed based on an idea that interests them, and *selection by attraction*, where different ideas are pitched and participants choose the idea they prefer. Ideas for projects could also be proposed by stakeholders and organizers.

After teams are formed, participants commonly begin working on their projects. For that, they could use various techniques such as agile programming [9], rapid iteration [50], and testing [28, 48]. It is also common to run energizing activities [6, 48], breaks [11, 48], and networking activities [11, 33, 48] during a hackathon to lift the moods of the participants.

During hacking, participants typically receive feedback from mentors [44] and sometimes, stakeholders that are also involved in the hackathon [5]. If a hackathon takes place as a competitive event, feedback [24] can also be provided by the jury, who evaluates projects and selects winner teams that receive prizes [29].

5 Discussion

In this section, we elaborate on the current understanding of the relationships between hackathon design aspects and outcomes, thus, answering RQ3. We start by elaborating on connections between hackathon outcomes and design aspects (section 5.1), before outlining activities that have been discussed in prior work related to hackathon outcomes (section 5.2), and addressing gaps in current literature (section 5.3).

5.1 Connections between hackathon outcomes and design aspects (RQ3)

The following connections have been found between hackathon outcomes and design aspects and may potentially influence future sustainability (Table 2).

Table 2. Connections between hackathon outcomes and design aspects

ID	Hackathon outcomes	Hackathon design aspects
O1, O2	Technical and non-technical artifacts	Duration [11, 50]
O1	Technical artifacts	Team size [12]
O1	Technical artifacts	Stakeholder connection [22, 30, 34]
O1	Wide range of solutions	Participant's skills [41]
O3	Learning and productivity	Duration [33]
O4	Networking	Participant's skills [38]

Technical and non-technical artifacts.
The following design aspects have been found to be related to the continuation of technical and non-technical artifacts: Hackathon duration, team size, connections with stakeholders and skills of the participants.

Hackathon duration. Cobham et al. and Nandi and Wilson et al. [11, 50] discuss the relationship between the duration of a hackathon and the quality of the artifacts that the hackathon teams developed. Cobham et al. [11] argue that the duration of 48 hours allowed for periods of rest and relaxation, while still leaving sufficient time for participants to develop elaborate prototypes. Wilson et al. [50], similarly argue that an extended duration allowed participants *"to develop their ideas, flesh them out more fully in their pitches, and engage other groups with questions, ideas, and feedback"* [50].

Team size. Cobham et al. [12] reported difficulties related to self-organization, task distribution and payment [12] for a winning team composed of 11 participants. In this case, there were more team members than tasks needed to be completed, which meant that "*too often some members were idle awaiting others to complete dependent tasks*" [12]. It would thus seem that a sustainable hackathon team requires that each member contributes equally to the development of the project using appropriate task assignment and management.

Connections with stakeholders. Linnell et al. [30] found that a strong relationship between hackathon organizers and potential users can ensure that *"the systems built will genuinely meet the needs of the clients"* [30], which could potentially lead to the sustainability of technical artifacts. Similarly, Gama et al. [22] found that *"having a person from the target audience made the participants more confident about their app than in the previous hackathon"* [22] thus drawing a potential connection between stakeholder input and the quality of the technical artifact developed during the hackathon. Nolte et al. [34] also reported that connections between stakeholders and hackathon teams can contribute to project continuation.

Skills of the participants. Rosell et al. [41] found that allowing for a high degree of diverse participants resulted, in turn, in a wide range of diverse solutions.

Learning.
Learning as an outcome has not been extensively studied in the context of research on hackathons. Gama et al. [21] however highlight that while participants *"break barriers to learn other technologies"*, learning at the hackathon occurred superficially *"due to the short time frame"* thus pointing to the necessity for participants to continue learning after an event has ended.

Networking.
Pirker et al. [38] found that "*programmers, hardware experts, or 2D artists are growing their social network slower"* [38] compared to audio engineers and other participants with different skill sets. They have also claimed that further investigation is necessary to identify the cause.

5.2 Activities to sustain hackathon outcomes

There are reports of approaches to sustain hackathon outcomes after a hackathon has ended. For instance, in order to sustain the development of technical artifacts that were created in the hackathon, organizers have offered: Coaching and mentoring to the winning teams [1, 35], a showcase of technical artifacts developed during an event at a forum [1], post-hackathon prizes [31, 35], the release of the productive version of technical artifacts [1, 20], recruitment of new team members [35], and grant writing [35].

However, little is known about the long-term impact that these post-hackathon activities had on outcome sustainability. There is still a need to e.g. understand effective mentoring approaches that could be applied after a hackathon ends. Moreover, most prior work on continuation focuses on hackathon projects, while how to sustain, for example, interdisciplinary collaboration is still not well understood.

It might also be important to consider different types of awards for winning teams. It is still unclear if different types of awards would lead to different levels of commitment and engagement from participants. To date, if hackathon organizers were to choose between different types of awards, there are limited insights into the extent to which each type could encourage participants to e.g. continue working on their projects.

In order to sustain networking after the hackathon had ended, participants can join a mailing list [46], but the extent to which a mailing list can sustain networking remains questionable. The lack of studies about sustaining networking for participants has also been addressed by Trainer et al. [49] who proposed three ways to support networking: (1) collecting data from mailing lists and source code-depositories (contributors and number of contributions) to *"construct social networks representing the social structure of a hackathon"* [49], (2) finding connections with people outside the hackathon i.e. to find stakeholders outside the environment of the hackathon to reveal a potential network amongst participants, stakeholders and end users, and (3) *"focus[ing] on practices and technologies for hackathon participants"* [49], where a certain technological tool could be used, for example, to share pictures of the event towards *"repeated exposure"*, which can fortify already established social ties.

In order to retain and expand the awareness of the theme of the hackathon, organizers have advertised outcomes [48] by e.g. presenting technical artifacts at a fair [20]. They have also encouraged participants to report and present their outcomes at conferences and workshops [9]. Albeit these pursuits have been perceived as successful or effective, there is limited evidence towards their feasibility as of this point.

While the impact of different activities is still unknown, it has been suggested that entrepreneurship can be successfully sustained by involving participants in business accelerators and entrepreneurial bootcamps [35]. The feasibility of this approach has not been extensively studied yet.

In addition to preparing activities to sustain the outcomes after the hackathon ends, there has been cases where organizers prepare activities before the hackathon begins. For instance, Nolte et al. [34] reported that preparation prior to a hackathon can influence the continuation of hackathon projects [34]. They particularly pointed towards teams discussing projects with related stakeholders prior to an event and teams engaging in expertise focused learning. Moreover, Rosell et al. [41] found that *"pre-hackathon training and orientation sessions"* allowed participants *"to feel comfortable with the technology"* during the hackathon. Finally, Trainer et al. [49] reported that participants meeting before a hackathon can foster team familiarity and collective task creation before forming teams.

5.3 Gaps in previous work on hackathon outcome sustainability

While various connections have been identified between hackathon outcomes and design aspects (c.f. section 5.1), there are also considerable gaps in current research related to the sustainability of hackathon outcomes (for an overview, see Fig. 2).

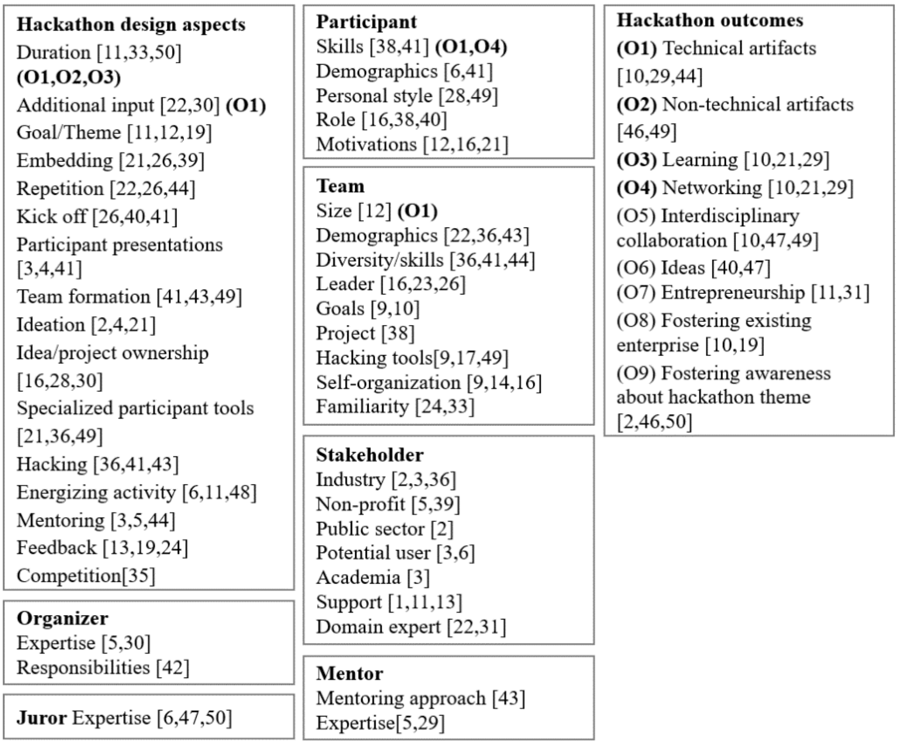

Fig. 2. Overview of hackathon design aspects and previously addressed connections between them. The code of the outcome (e.g. O1) placed next to a design aspect represents a potential connection with that outcome and that hackathon design aspect.

There are limited insights into how **the goals of the participants** could affect, for instance, ideation, team formation, or hacking. It is still uncertain how participant goals [32] relate to their behavior during hackathons and how their individual goals can affect the sustainability of outcomes.

The **goals of hackathon organizers** also certainly affect the design of a hackathon which can potentially influence the sustainability of hackathon outcomes [5, 30]. But there is limited evidence related to how their goals can affect design decisions and in turn influence the sustainability of hackathon outcomes.

Mentors in hackathons have also not been extensively studied yet. While scholars recognize their importance, current research work focuses on their expertise and mentoring approach [5, 29, 43] without elaborating on their goals, previous hackathon experience and background and the potential effects of these on their mentoring approach and subsequent hackathon outcomes.

Moreover, hackathons are sometimes conducted repeatedly. This allows organizers to learn and improve their design. However, it is still unclear how **the repetition of a hackathon** can influence the sustainability of hackathon outcomes.

Hackathons can also be included as a part of a series of events. For instance, at the beginning of a project for development of the skills of the participants, towards the middle for data analysis, or towards the end [23]. However, the influence **of being part of a series of events** on hackathon sustainability is still unknown.

The ideas, and therefore, projects that come as a result of hacking may belong to the participants, but also to the organizers, or stakeholders. How the perceived **ownership of an idea** can potentially influence outcome sustainability is not well understood. Moreover, Filippova et al. [18] found that *"brainstorming impacts satisfaction with outcome indirectly by increasing clarity of goals"* [18], however, details regarding the particulars of the **ideation** process during hackathons are still missing.

While Ghouila et al. [23] and Ferguson et al. [17] mentioned that participants would have wanted more time for improving the quality of their final projects, the impact of different **hackathon durations** remains understudied. In addition, Ghoulia et al. [23] stated that by establishing a strong **intrateam relationship**, teams may be more likely to continue working together after the hackathon ends. They do however not provide any specifics related to the tools or methods that could be used to support the sustainability of connections made during a hackathon. The lack of **specific tools to support intrateam communication** has also been addressed by Hou and Wang [25]. They stated that a CSCW system is necessary in hackathons for expert collocation and knowledge sharing. Likewise, Karlsen and Løvlie [26] mentioned the importance of providing participants with tools to support collaboration. Similarly, Trainer et al. [49] addressed the importance of tools to *"support preparation and bring the results into the hackathon in a usable form"* [49] as well as tools to capture the progress made at the hackathon to seamlessly continue it afterwards.

While previous research work has mainly focused on the potential sustainability of technical artifacts, little attention has been payed to the sustainability of non-technical artifacts, ideas, interdisciplinary collaboration and fostering existing enterprise.

5.4 Limitations

Since the aim of our study was to develop a systematic overview of the current state of the art related to hackathon outcomes, hackathon design aspects and their interconnection, we chose to use conduct a systematic literature review. Despite following well established guidelines this study design has inherent limitations. It only allows us to discover published academic work thus leaving out potentially interesting insights from practitioners that have not been published yet. Moreover, the review was conducted by a group of researchers which makes it subject to interpreter bias. We attempted to mitigate this bias by collaboratively analyzing the identified paper over multiple iterations. Finally, we limited out search to a specific subset of online libraries, using specific search strings and filtering our findings based on specific inclusion and exclusion criteria. Different sources, search strings and inclusion and exclusion criteria might have yielded different results.

6 Conclusion and Future Work

We conducted a systematic literature review to identify previously addressed hackathon outcomes, hackathon design aspects and the connections between them. Based on our findings we developed an overview of previously addressed hackathon outcomes (Table 1), and hackathon design aspects (Fig. 1), discussed their connections and identified gaps in prior literature (section 5). We found that most research work focuses on the sustainability of technical artifacts, while there are other kinds of hackathon outcomes left unstudied. Moreover, many design aspects such as the goals of participants, organizers and mentors have not been explored in relationship to hackathon outcomes.

To expand our work we are currently planning an interview study with hackathon organizers, mentors and participants to identify potential outcomes and design aspects that have not been addressed by prior research. Combining the findings from the planned study and the findings presented in this paper we will develop a model of interconnected factors that can foster the sustainability of hackathon outcomes.

References

1. Alba, M. et al.: Synergy between smart cities' hackathons and living labs as a vehicle for accelerating tangible innovations on cities. In: 2016 IEEE International Smart Cities Conference (ISC2). pp. 1–6 IEEE, Trento (2016).
2. Amugongo, L.M. et al.: Increasing Open Data Awareness and Consumption in Namibia: A Hackathon Approach. In: Cross Media. p. 13 , Berlin (2015).
3. Angelidis, P. et al.: The hackathon model to spur innovation around global mHealth. Journal of Medical Engineering & Technology. 40, 7–8, 392–399 (2016).
4. Aryana, B. et al.: Strategies for Empowering Collective Design. The Design Journal. 22, sup1, 2073–2088 (2019).
5. Birbeck, N. et al.: Self Harmony: Rethinking Hackathons to Design and Critique Digital Technologies for Those Affected by Self-Harm. In: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI '17. pp. 146–157 ACM Press, Denver, Colorado, USA (2017).
6. Boisen, Kirsten & Boisen, Anne & Thomsen, Stine & Matthiesen, Simon & Hjerming, Maiken & Hertz, Pernille: Hacking the hospital environment: Young adults designing youth-friendly hospital rooms together with young people with cancer experiences. International journal of adolescent medicine and health. (2015).
7. Brereton, P. et al.: Lessons from applying the systematic literature review process within the software engineering domain. Journal of Systems and Software. 80, 4, 571–583 (2007).
8. Briscoe, G., Mulligan, C.: Digital Innovation: The Hackathon Phenomenon. Creativeworks London. 13 (2014).
9. Chandrasekaran, S. et al.: Best Practices in Running Collaborative GPU Hackathons: Advancing Scientific Applications with a Sustained Impact. Comput. Sci. Eng. 20, 4, 95–106 (2018).
10. Chandrasekaran, S. et al.: The OLCF GPU Hackathon Series: The Story Behind Advancing Scientific Applications with a Sustained Impact. EduHPC-17: Workshop on Education for High-Performance Computing (2017).
11. Cobham, D. et al.: From Appfest to Entrepreneurs: Using a Hackathon Event to Seed a University Student-Led Enterprise. International Technology, Education and Development Conference, Valencia, Spain March (2017).

12. Cobham, D. et al.: From Hackathon to Student Enterprise: An Evaluation of Creating Successful and Sustainable Student Entrepreneurial Activity Initiated by a University Hackathon. International Conference on Education and New Learning Technologies, Barcelona, Spain March (2017).
13. Dainotti, A. et al.: The BGP hackathon 2016 report. SIGCOMM Comput. Commun. Rev. 46, 3, 1–6 (2018).
14. Day, K. et al.: How do the design features of health hackathons contribute to participatory medicine? AJIS. 21, (2017).
15. Drouhard, M. et al.: A Typology of Hackathon Events. Conference on Computer-Supported Cooperative Work and Social Media (2017).
16. Farhan, E., Kocher, M.: Big Team Game Jams: A framework to emulate big production using game jams with big teams. In: Proceedings of the International Conference on Game Jams, Hackathons, and Game Creation Events - GJH&GC '16. pp. 1–7 ACM Press, San Francisco, CA, USA (2016).
17. Ferguson, A.L. et al.: Conference report: 2018 materials and data science hackathon (MATDAT18). Mol. Syst. Des. Eng. 4, 3, 462–468 (2019).
18. Filippova, A. et al.: From Diversity by Numbers to Diversity as Process: Supporting Inclusiveness in Software Development Teams with Brainstorming. In: 2017 IEEE/ACM 39th International Conference on Software Engineering (ICSE). pp. 152–163 IEEE, Buenos Aires (2017).
19. Flores, M. et al.: How Can Hackathons Accelerate Corporate Innovation? In: Moon, I. et al. (eds.) Advances in Production Management Systems. Production Management for Data-Driven, Intelligent, Collaborative, and Sustainable Manufacturing. pp. 167–175 Springer International Publishing, Cham (2018).
20. Frey, F.J., Luks, M.: The innovation-driven hackathon: one means for accelerating innovation. In: Proceedings of the 21st European Conference on Pattern Languages of Programs - EuroPlop '16. pp. 1–11 ACM Press, Kaufbeuren, Germany (2016).
21. Gama, K. et al.: Hackathons in the formal learning process. In: Proceedings of the 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education - ITiCSE 2018. pp. 248–253 ACM Press, Larnaca, Cyprus (2018).
22. Gama, K. et al.: Mapathons and Hackathons to Crowdsource the Generation and Usage of Geographic Data. In: Proceedings of the International Conference on Game Jams, Hackathons and Game Creation Events 2019 - ICGJ 2019. pp. 1–5 ACM Press, San Francisco, CA, USA (2019).
23. Ghouila, A. et al.: Hackathons as a means of accelerating scientific discoveries and knowledge transfer. Genome Res. 28, 5, 759–765 (2018).
24. Horton, P.A. et al.: Project-Based Learning Among Engineering Students During Short-Form Hackathon Events. American Society for Engineering Education Annual Conference & ExpositionAt: Salt Lake City, UT (2018).
25. Hou, Y., Wang, D.: Hacking with NPOs: Collaborative Analytics and Broker Roles in Civic Data Hackathons. Proc. ACM Hum.-Comput. Interact. 1, CSCW, 1–16 (2017).
26. Karlsen, J., Løvlie, A.S.: 'You can dance your prototype if you like': independent filmmakers adapting the hackathon. Digital Creativity. 28, 3, 224–239 (2017).
27. Kitchenham, B. et al.: Systematic literature reviews in software engineering – A systematic literature review. Information and Software Technology. 51, 1, 7–15 (2009).
28. Lara, M. et al.: Peer-Led Hackathon: An Intense Learning Experience. (2015).
29. Lara, M., Lockwood, K.: Hackathons as Community-Based Learning: a Case Study. TechTrends. 60, 5, 486–495 (2016).

30. Linnell, N. et al.: Hack for the homeless: A humanitarian technology hackathon. In: IEEE Global Humanitarian Technology Conference (GHTC 2014). pp. 577–584 IEEE, San Jose, CA (2014).
31. Mantzavinou, A. et al.: Health Hackathons Drive Affordable Medical Technology Innovation Through Community Engagement. In: Hostettler, S. et al. (eds.) Technologies for Development. pp. 87–95 Springer International Publishing, Cham (2018).
32. Medina Angarita, M.A., Nolte, A.: Does it matter why we hack? – Exploring the impact of goal alignment in hackathons. 16 (2019).
33. Nandi, A., Mandernach, M.: Hackathons as an Informal Learning Platform. In: Proceedings of the 47th ACM Technical Symposium on Computing Science Education - SIGCSE '16. pp. 346–351 ACM Press, Memphis, Tennessee, USA (2016).
34. Nolte, A. et al.: You Hacked and Now What?: - Exploring Outcomes of a Corporate Hackathon. Proc. ACM Hum.-Comput. Interact. 2, CSCW, 1–23 (2018).
35. Olson, K.R. et al.: Health hackathons: theatre or substance? A survey assessment of outcomes from healthcare-focused hackathons in three countries. BMJ Innov. 3, 1, 37–44 (2017).
36. Page, F. et al.: The Use of the "Hackathon" in Design Education: An Opportunistic Exploration. Engineering and Product Design Education (2016).
37. Pe-Than, E.P.P. et al.: Designing Corporate Hackathons With a Purpose: The Future of Software Development. IEEE Softw. 36, 1, 15–22 (2019).
38. Pirker, J. et al.: Social Aspects of the Game Development Process in the Global Gam Jam. In: Proceedings of the International Conference on Game Jams, Hackathons, and Game Creation Events - ICGJ 2018. pp. 9–16 ACM Press, San Francisco, CA, USA (2018).
39. Porter, E. et al.: Reappropriating Hackathons: The Production Work of the CHI4Good Day of Service. In: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI '17. pp. 810–814 ACM Press, Denver, Colorado, USA (2017).
40. Purwanto, A. et al.: Citizens' Motivations for Engaging in Open Data Hackathons. In: Panagiotopoulos, P. et al. (eds.) Electronic Participation. pp. 130–141 Springer International Publishing, Cham (2019).
41. Rosell, B. et al.: Unleashing innovation through internal hackathons. In: 2014 IEEE Innovations in Technology Conference. pp. 1–8 IEEE, Warwick, RI (2014).
42. Sadovykh, A. et al.: On the Use of Hackathons to Enhance Collaboration in Large Collaborative Projects : - A Preliminary Case Study of the MegaM@Rt2 EU Project -. In: 2019 Design, Automation & Test in Europe Conference & Exhibition (DATE). pp. 498–503 IEEE, Florence, Italy (2019).
43. Safarova, B. et al.: Learning from Collaborative Integration. 33rd eCAADe Conference (2015).
44. Soltani, P. et al.: Hackathon – a method for Digital Innovative Success: a Comparative Descriptive Study. In: Proceedings of the 8th European Conference on Information Management and Evaluation, ECIME 2014. (2014).
45. Starov, O. et al.: Hacking the Innovations with University-Industry Hackathons. University-Industry Interaction Conference (2015).
46. Stoltzfus, A. et al.: Community and Code: Nine Lessons from Nine NESCent Hackathons. F1000Res. 6, 786 (2017).
47. Suominen, A.H. et al.: Educational Hackathon: Innovation Contest for Innovation Pedagogy. Innovation, the Name of the Game: Proceedings of the 2018 ISPIM Innovation Conference (Stockholm). 18 (2018).

48. Tang, T., Vezzani, V.: Fostering a culture of collaboration through playful Design Jams. 9th International Conference, Senses & Sensibility 2017: Design Beyond Borders and Rhizomes (2017).
49. Trainer, E.H. et al.: How to Hackathon: Socio-technical Tradeoffs in Brief, Intensive Collocation. CSCW (2016).
50. Wilson, J. et al.: Beyond the Classroom: The Impact of a University-Based Civic Hackathon Addressing Homelessness. Journal of Social Work Education. 55, 4, 736–749 (2019).