An exploratory study of experiences of design at hackathons

by

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A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Master of Applied Science
in
Management Sciences

Waterloo, Ontario, Canada, 2021

AUTHOR'S DECLARATION

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

Meagan Flus was the sole author for Chapters 2, 4, 5 and portions of Chapters 3, which were written under the supervision of Dr. Ada Hurst and were not written for publication.

This thesis consists in part of two manuscripts written for publication, with major changes to the material for the thesis. Exceptions to sole authorship of material are as follows:

Research presented in Chapter 1 and Appendix A:

This research was conducted at the University of Waterloo by Meagan Flus under the supervision of Dr. Ada Hurst. Meagan Flus designed the literature review, completed the data analysis, and drafted the manuscript. Dr. Hurst provided intellectual input on manuscript drafts.

Citation:

Flus, M., & Hurst, A. (2021). Design at hackathons: New opportunities for design research. *Design Science*, 7, E4. doi:10.1017/dsj.2021.1

Research presented in Chapter 3:

The research presented in this chapter is an extension of the preliminary study conducted at the University of Waterloo by Meagan Flus under the supervision of Dr. Ada Hurst. The work in the thesis includes an extra six transcripts and more detailed analysis than the manuscript which it is based on. Meagan Flus designed the study with consultations from Dr. Hurst. Meagan Flus conducted the data analysis and drafted the manuscript. Dr. Hurst provided feedback on the manuscript drafts.

Citation:

Flus, M., & Hurst, A. (2021) Experiences of Design at Hackathons: Initial Findings from an Interview Study. *Proceedings of the Design Society: 23rd International Conference on Engineering Design (ICED21)*.

Abstract

Hackathons are popular events where participants "hack" together a project, from ideation through to the final presentation, in 24-48 hours. It is typical for hackathons to be tech-centric; therefore, the attendees tend to be mostly computer programmers, designers, and engineers. Hackathons have been hosted by communities, corporations, and educational institutions with goals of producing artifacts or products, networking, and learning. Hackathons are inherently collaborative, as attendees typically work together in small groups. The participants depend on team skills to complete their projects in the short event time frame.

Hackathons hold a lot of potential for design research; however, the community has been slow to recognize the potential research opportunities. The existing research on design at hackathons is limited, despite the consideration of hackathons as a setting where participants engage in design activity. Motivated by the popularity of hackathons and the lack of significant research on design at hackathons, this thesis presents an exploratory research of hackathon participants' experiences of design at these unique events. The research is motivated by three main research questions: 1) what are the characteristics of the design process followed by hackathon participants, 2) how does the design process at hackathons differ from more typical design projects, and 3) how does team composition impact the design experience at hackathons?

To answer these research questions, 16 semi-structured interviews were conducted with participants who had collectively participated in 65 hackathons. The transcripts of the interviews underwent a thematic analysis, a methodology that identifies themes in the dataset. Codes were assigned to interview transcripts, resulting in 90 codes on 684 excerpts. The codes were then clustered thematically to identify five major themes: the typical hackathon experience, design at hackathons, collaboration, evaluation of hackathons, and miscellaneous. These themes informed the findings of the study and their presentation in this thesis.

Interview results suggest that the main stages of the design process at hackathons are ideation, building, and pitch preparation and delivery. While some research, including user research, and design iteration activities may occur, the short time frame of the hackathon severely limits these activities and forces participants to instead prioritize the building phase. Further, due to the continuous nature of the event, participants are not able to take significant breaks from their design tasks, thus not benefiting from potential incubation periods. It is concluded that while hackathons

share many characteristics of the design process with more typical design projects, the nature of these events causes the design processes to be adapted in significant ways.

Team composition is found to be highly influential in the projects and processes of hackathon teams. Participants' motivations for attending hackathons - to win, network, learn, or have fun - play a role in what activities they participate in at the events and how they approach their hackathon design project. Motivations for attending, along skills and interest are an important factor considered in team formation. Hackathon teams tend to comprise of three roles: developer, designer, and business analyst, which are determined based on knowledge and experience. The interviews reveal conflict between developers and designers based on their desired approaches to the hackathon design process. Whereas developers are eager to begin building almost immediately, designers encourage a more thorough progression through the design process.

The contributions of this thesis hold implications for hackathon participants and organizers, design researchers, and design educators. The research frames hackathons as design-centered settings that generate rich data. As an exploratory study, the research builds a foundational understanding of design at hackathons, offering a new direction for design research and prompting a number of future research opportunities.

Acknowledgements

I would like to thank my supervisor, Dr. Ada Hurst, for her unwavering support and guidance throughout my masters. From the moment she encouraged me to pursue graduate education, she has been my biggest mentor and a devoted advisor. Her guidance has made me a better researcher and a more inspired thinker. I could not have asked for a better, more engaged advisor.

I would also like to thank my readers, Dr. Frank Safayeni and Dr. Rob Duimering for their time and insight.

A sincere thank you to Gregory Litster and Jordan Nickel. Your willingness to act as sounding boards was helpful beyond measure, and your companionship and support were unmatched. I plan to take full advantage of opportunities to collaborate in our futures. Until then, I am always available for virtual yoga. I would also like to thank my friends, in particular, Keira Chadwick for offering a fresh set of eyes and ears when I needed them, and Elisabeth Martin del Campo for being my biggest cheerleader.

Finally, thank you to my family who believed and supported me throughout this journey. My parents graciously welcomed me home and kept me sane during the COVID-19 lockdowns. Even before a global pandemic, they believed in me and trusted that I would find my way in a highly ambiguous world. Their encouragement to question everything and find my own answers has brought me here, and I am forever grateful.

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Chapter 1
Introduction and background

Hackathons are an untapped design research opportunity, despite rapidly growing in popularity. At these events, participants work in small groups to ideate, develop, and present a solution to an identified problem, all within a short, continuous time-frame of typically one to two days. Hackathons have only recently come into research focus (Trainer et al., 2016). Studies have investigated the individual experiences of participants (Olesen et al., 2018), the effect of expertise diversity in hackathon teams (Legardeur et al., 2020), and the use of hackathons to solve problems (Artiles & LeVine, 2015; Kos, 2019b; Lewis et al., 2015; Uffreduzzi, 2017), teach design (Fowler, 2016; Gama et al., 2019; Nandi & Mandernach, 2016; Page et al., 2016), and facilitate design processes (Artiles & Wallace, 2013).

Hackathons are a setting that simulates aspects of design activity as it occurs in real-life practice. The unique characteristics of hackathons, in particular their short duration, frame them as heightened and condensed design-centered events at which design processes are challenged and adapted. Yet, the extent and nature of design in this unique environment is not well understood. Research on design activity as it occurs at hackathons can improve the understanding of rapid design decision-making and is a logical extension of design research. A better understanding of design at hackathons can help clarify how these events engage participants in the design process (Olesen et al., 2018), shed light on the impact of a hackathon's format on participants' ideation, design judgement, and design knowledge, and reveal how the design process is adapted in this unique environment. Studying how hackathon participants design can also more broadly enrich the understanding of how designers think during an applied design task when under significant time pressure.

This thesis is an exploratory study on design activity at hackathons. It aims to achieve a foundational understanding of the characteristics of the design processes followed by participants at these events to support future design research in this unique setting. This is achieved with a thematic analysis on transcripts from 16 semi-structured interviews with hackathon participants. This study offers first-hand accounts of design activity at hackathons from a diverse study population and offers support to existing literature on hackathons while presenting new findings that highlight the potential of hackathons as a future direction of design research. As hackathons become more popular, it is becoming increasingly popular to fully understand what happens at these events. Therefore, this research is motivated by the emerging popularity of hackathons, a lack of an established understanding of design at hackathons, and a curiosity on how the unique environment of hackathons, mainly the limitations of time and resources, impacts the design process.

1.1 What is a hackathon?

There are no agreed-upon characteristics that classify an event as a hackathon (Komssi et al., 2015), making it difficult to generate a definition inclusive of all variations of hackathon-like events. In general, a hackathon is a problem-focused, short-term event where small groups work to develop a final product, typically a software project (Briscoe & Mulligan, 2014; Gama, 2017; Izvalov et al., 2017; Kollwitz & Dinter, 2019; Komssi et al., 2015). It is typical for the theme of hackathons to be tech-centric; as such, these events tend to be of interest to computer programmers, designers, and engineers.

The term “hackathon” is a combination of the words “hack” and “marathon” (Briscoe & Mulligan, 2014); whereas the usual interpretation of “hack” is in reference to a cybercrime, in this context it refers to quick, exploratory programming. The term “marathon” implies a prolonged, race-like event. This accurately describes a hackathon as a tech-centric, speed design event.

Since the first known uses of the term “hackathon” to describe events in 1999 (Briscoe & Mulligan, 2014; Richterich, 2019), the hackathon phenomenon has rapidly expanded, with 5,636 hackathons organized globally in 2018 (Find & Organize Hackathons Worldwide, n.d.) hosting upwards of 1500 participants at each event (Hack the North, n.d.). Hackathons may also be referred to as game jams, design jams, hacking festivals, hack days, design sprints and codefests (Briscoe & Mulligan, 2014), among others. As the hackathon format continues to be adapted for different uses and by different stakeholders, new names continue to emerge. In this thesis, hackathons that are not labelled as such, but follow a format inspired by hackathons, are considered “hackathon-like events.”

Due to their versatility, hackathons and the hackathon format have been adopted in a wide variety of contexts, such as in communities (e.g., Taylor et al. (2017)), in corporations (e.g., Saravi et al. (2018)), and in educational institutions (e.g., Gama et al. (2019), Page et al. (2016), Rennick et al. (2018)). Further, the COVID-19 pandemic has seen an increase in the number of online hackathons (e.g., Braune et al. (2021)). Hackathons have also served different purposes, including education, networking, and to accelerate innovation (Flores et al., 2018). The most common goals of hackathons are the production of artifacts or products, networking, and learning (Nolte et al., 2020). Hackathons could be run as external events (open to anyone), or internally by organizations (Briscoe & Mulligan, 2014). The context of the event and event goal are closely linked; for example, a hackathon held in a curricular setting will most likely have the goal of facilitating learning. The duration of hackathons can also vary greatly. Hackathons typically run continuously over 24-36 hours, but may also run for shorter periods of time, for example within a standard 9-5 workday, or over a span of weeks, months, or even years (De Oliveira et al., 2019; Hölttä-Otto et al., 2018; Rennick et al., 2018; Richterich, 2019; Taylor et al., 2018; Truyen et al., 2017). The extreme time pressure often influences participants to work overnight, and hackathons tend to be loud, high-intensity environments, making them unique settings in which design occurs.

Hackathons have much in common with a related approach to design – Agile – which also prioritizes the creation of working solutions over a short time scale, in periods of design termed 'sprints' (Sims & Johnson, 2011, p. 40). Not surprisingly, many organizations that have already adopted agile practices will also use hackathons and hackathon-like events to accelerate innovation (Alkema et al., 2017). Prior studies have reported the emergence of agile practices during hackathons (Alkema et al., 2017), and attempts to integrate hackathon and agile approaches into one event (Ferrario et al., 2014; Hölttä-Otto et al., 2018). The goal of design sprints as they are typically described in the literature is innovation within a specific organizational context; as such they are integrated with or complementary to existing organizational processes, and operate at different time-scales of 1-4 weeks (Knapp et al., 2016, p. 40). Of interest in this thesis are the hackathons that follow the more typical structure – a large number of participants gathering over a short period of time (1-2 days) to engage in a design activity that is separate from their regular commitments, whether school or work. As such, the majority of hackathons studied in the literature informing the background of this thesis are either community events or educational hackathons.

1.2 What do hackathons mean for design research?

Design reasoning has commonly been conceptualized as the process of developing an artefact (the "what") that performs some function (the "how") in order to solve the problem (the "outcome") (Dorst, 2011). The designer must start with the desired "outcome" and devise a new "how", and in turn, design the "what", a pattern known as design abduction (Dorst, 2011). The typical design problem is ill-structured, meaning it is not well-defined, the goals are underspecified, and the potential solutions are practically limitless (Goel & Pirolli, 1992). The formulation of such "wicked" problems cannot follow a linear path (Rittel & Webber, 1973); design entails a continuous refinement of both the designer's understanding of the problem and their ideas for solving it, in a process of co-evolution of the problem and solution spaces (Dorst & Cross, 2001; Maher et al., 1996). In other words, a designer must shift their thinking between the required purpose/function and the appropriate ways to satisfy that purpose. Since there are two unknowns in design abduction (the "what" and the "how"), there is a lot of uncertainty and limited knowledge, making design a long and iterative creative process (Dorst, 2011).

Hackathons are structured as abductive tasks – participants may spend significant time "searching" for a problem for which a solution must be designed. The recognition of hackathons as design-centered activities and the popularity of hackathon events presents promising opportunities for research. Since the 1960s when it first emerged as a discipline, design's development and impact on industry, research, and education has occurred in a number of "waves" (Cooper, 2019). The emergence of hackathons in the 1990s and their further gains in popularity in the 2000s (Briscoe & Mulligan, 2014; Richterich, 2019) coincide with the cusps of the third wave of change, a time of formalizing the connection between design and innovation, and the fourth wave, a time of the acceptance of design outside of the discipline (Cooper, 2019). The increasing interest in hackathons also aligns with the current (fifth) wave - applying design to understand the future (Cooper, 2019) – as hackathon events increasingly challenge participants to solve complex problems with a focus on benefitting the world and our futures; for example, solving systemic healthcare problems (Alamari et al., 2019), addressing sustainability issues such as deforestation (Lodato & DiSalvo, 2015), and conceptualizing products or services to aid those affected by self-harm (Birbeck et al., 2017). Therefore, hackathons are a promising and relevant avenue for design research.

There are two main approaches to studying design – field studies (e.g., observational studies in design practice, or interviews with design practitioners) and experiment studies. Design studied in field studies is authentic, but those studies require a long-term investment from the researchers because design projects are long and require cooperation with organizations. Experiment studies can be easier to run since they are shorter in duration and require the involvement of individuals, not necessarily organizations, but the design tasks are not authentic and participants' investment in the design is artificial. Hackathons emerge as an attractive third option. Their short duration increases the feasibility of conducting studies of design in this setting. At the same time, participants are self-motivated in their participation at the hackathon and in designing something they have chosen themselves, making the design task more authentic than what is typically studied in controlled experiments (McMahon, 2012). Therefore, hackathons present a "best-of-both-worlds" scenario for design research where the design is more authentic than in experimental studies, but easier to control than in field studies. However, many of the benefits of employing hackathons for research are met with corresponding challenges. For instance, the short duration of the events, which involves a short time investment from the researchers, also affects the participants' behaviours. The condensed time frame limits participants' ability to engage with the entire design process thoroughly. This is arguably the most significant limitation to studying design at hackathons – the design process presents unique characteristics that differentiate it from "real-life" design.

1.3 Review of the literature on design at hackathons

A systematic review of the literature was conducted with the aim of gaining a broad understanding of what is known on the topic of designing at hackathons. Systematic reviews can only be conducted within established fields and the literature on design at hackathons is limited. Nevertheless, the PRISMA framework (Moher et al., 2009) was employed as a means to structure the review. This framework prescribes a four-phase process for conducting systematic literature reviews, as shown in Figure 1.

Key search terms were identified as "hackathon", "design" (intended to encompass other terms such as design thinking, design process, design cognition, design activity), and "creative" (to encompass creativity, creative thinking, creative process). While hackathons have also been identified with alternate names, such as game jams and hack days, these were eventually omitted from the search as "hackathon" was found to encompass these words in the search results. The search was conducted on November 19, 2019 in the Scopus and Web of Science research databases. The terms were searched in the "titles", "abstracts" and "keywords" fields. The inclusion criteria for the search were journal articles, conference proceedings, books, or book sections, published in English. The exact search syntax is provided in Table 1.

Table 1: Search syntax by database with number of results

Database	Search Syntax	Results
Scopus	(TITLE-ABS-KEY (hackathon*) AND TITLE-ABS-KEY (design OR creativ*)) AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))	232
Web of Science	TOPIC: (hackathon* AND (design OR creativ*)) Refined by: DOCUMENT TYPES: (PROCEEDINGS PAPER OR ARTICLE) AND LANGUAGES: (ENGLISH)	109

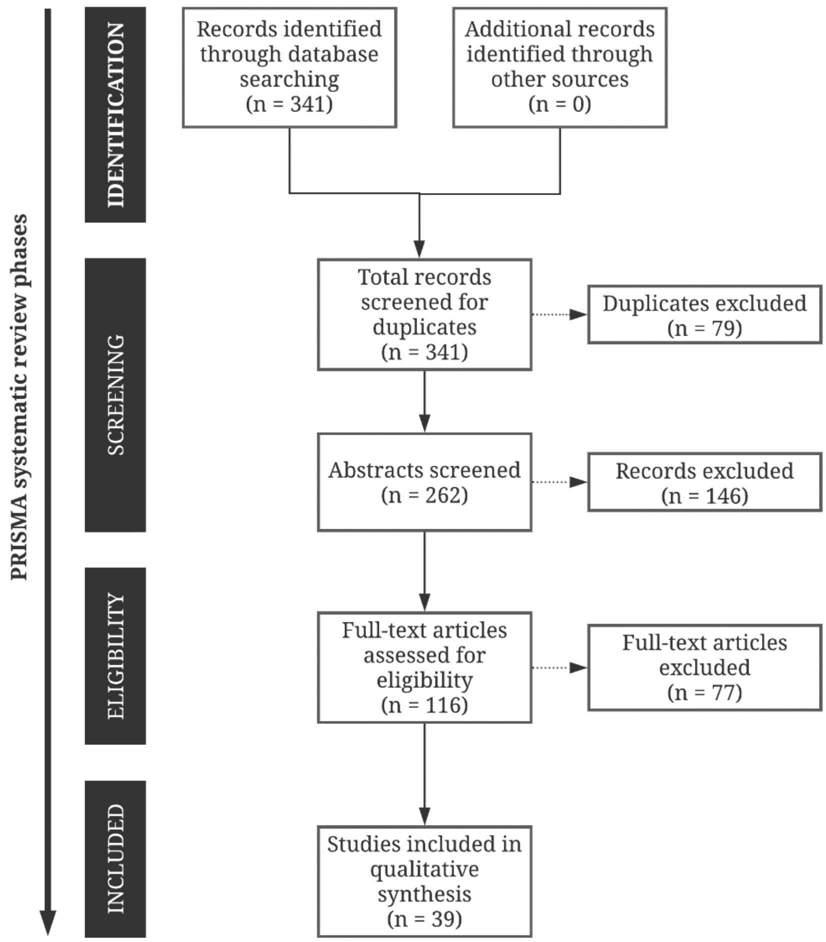


Figure 1: PRISMA flowchart of literature review

Searches in the Scopus and Web of Science databases yielded 232 and 109 results, respectively. After duplicates were removed, abstracts of the remaining 262 records were scanned for relevance. At this stage, 146 publications were removed because they were proceedings of presentations at a hackathon (not publications about design at hackathons), the hackathon was a means to study a different phenomenon, or the publication was not about a hackathon.

A full-text screen was then done on the remaining 116 publications to further screen for applicability. The main reason for exclusion at this stage was the lack of discussion about design activity. After this process, 39 publications were selected as relevant to the topic of study. Appendix A presents an overview of all reviewed publications and the hackathon(s) they study. What follows is an overview of the main design-related activities at hackathons, as synthesized from the review of the literature. The overview is a synthesis of the design process as informed by existing research studies. The described activities do not necessarily occur in the presented order, only once, by every team, at every hackathon. Instead, they are identified as patterns of activity by the publications' authors.

Typically, a hackathon starts with a presentation of the event goals, design challenges, sponsors, schedule, and prizes. The theme of the event can either be announced beforehand, or at the start of the event. Once at the event, the hackathon design process begins. At the beginning of a hackathon, the first activity of significance for participants is to form and get to know their teams, if they have not already formed these teams prior to the event. Once teams are formed, teams identify potential topics for their hackathon project. Depending on the hackathon, participants may be given a topic or prompt (e.g., "find solutions to 'smart villages and territories' problems" (Soligno et al., 2015, p. 737)), or may need to begin their design process by first identifying a problem area. It is typical for industry to partner with hackathon events, for example by having industry representatives attend hackathons and propose project areas. The highest degree of industry involvement is a company-internal hackathon, which is a hackathon exclusive to an organization's employees that aims to solve a shared problem. For example, at a hackathon hosted by a large IT provider in Germany, 24 employees from various departments split-up into 5 teams that competed to develop an app that supported the sharing of a "thing", such as a car or book (Frey & Luks, 2016). In this case, the goal of the hackathon projects was predetermined. In general, teams either identify their problems from the industry partners (where applicable), from their personal experience (e.g., Raatikainen et al. (2013), Suominen et al. (2019)), or from conducting user research (e.g., Damen et al. (2019), Karlsen & Løvlie (2017)). Teams brainstorm potential ideas and use strategies such as team voting to converge on a direction for their project (Thomer et al., 2016). Altogether, this phase comprises the "finding" of both the project topic and the design team itself. Hackathon participants engage in a process of perceiving the context (i.e., team and setting) to discover available resources – "space, skilled time, knowledge, and tools" (Prieto et al., 2019, p. 2) – to meet their goals.

In established design processes, the next step would be to construct an understanding of the problem and converge to a problem formulation that defines the aims and requirements of the design and constraints of the solution space. Requirements and constraints may come from the task environment or the designers themselves. In the hackathon setting, a large constraint is time, thus participants aim to identify a problem for which a viable solution can be developed in the short time frame of the event. Techniques highlighted in the reviewed publications for developing an understanding of the problem at hackathons include interviews and stakeholder mapping (Damen et al., 2019), as well as user profiling (Rey, 2017). These techniques allow for teams to identify key features and create a shared understanding of the problem within the group (Prieto et al., 2019). Completing this phase is needed in order for the team to establish a direction for the remainder of the design process (Damen et al., 2019).

At hackathons, solution design and building comprises two main tasks: 1) concept ideation (Damen et al., 2019), which is the generation of possible solution ideas and subsequent iteration on those ideas, and 2) embodiment (Prieto et al., 2019), which includes the developing and demonstrating initial prototypes. Common design tools used during this phase are sketching (Karlsen & Løvlie, 2017; Thomer et al., 2016), and other forms of prototyping (Karlsen & Løvlie, 2017; Rey, 2017; Suominen et al., 2019). Teams may use provided materials, such as Post-it Notes (Rey, 2017), to aid in brainstorming, and cheap supplies to build prototypes.

Once teams have chosen a project idea and built a suitable solution prototype, they will begin to test their designs, for example by assigning a "tester" role to a team member responsible for checking their code for bugs (Pe-Than & Herbsleb, 2019), or by asking volunteers at the event to use their prototype to identify any features that do not function as intended (Rey, 2017). Test results help determine the design's final functionality such that teams may have to remove some functionalities of their design in order to complete their projects on time (Rey, 2017). The testing and building phases are closely linked, and often, teams are observed cycling between the two phases. Once teams finish their evaluation and are satisfied with their results, they present their final design.

Hackathons tend to conclude with a final pitch competition, during which participants pitch their designs to a panel of judges (Gama et al., 2019) with the hopes of winning prizes and recognition. The presentation of a design solution to an audience (e.g., clients) is not unique to hackathons, but this activity is emphasized at hackathons where it takes up a significant portion of the event. Prizes are dependent on the pitch, thus teams will dedicate considerable resources to its development and final presentation (Richterich, 2019). With the exception of the few projects that win monetary prizes, the participants are unpaid. In fact, it was found that some hackathons hold a right to the ideas generated at the event, limiting the ability of participants to take their project further (Uffreduzzi, 2017).

The literature presented how the structure of the hackathon event itself can encourage and shape the design process followed by hackers during the event. Some hackathons offer participants workshops on specific design phases, such as ideation (Filippova et al., 2017; Lodato & DiSalvo, 2015). Other events encourage teams to follow an entire design process (Page et al., 2016), for example Design Thinking (as popularized by Brown (2008)) with an additional "pitch" phase (Flores et al., 2018). At these events, a prescribed design process is provided as an option to participants, but they are not required to follow it. Design instruction (e.g., workshops on design processes) that is offered to hackathon participants can promote teams' use of user-centered design practices (Page et al., 2016) and better following of established design process (Flores et al., 2018). Learning about the steps in a design process encourages participants to follow the process, which in turn, improves outcomes at hackathons (Aryana et al., 2019). Some hackathons include schedules or other types of structures that directly enforce a design process for participants. These hackathons divide the event into phases reflective of established design frameworks, such as Design Thinking (Alamari et al., 2019; Taratukhin et al., 2018), the Logical Framework Approach (Soligno et al., 2015), the Challenge-Based Learning Framework (Gama et al., 2019), and the Mechanics Dynamics Aesthetics framework (Buttfield-Addison et al., 2016). Finally, some hackathons impose a more general design structure by facilitating activities and requiring completion of certain tasks, such as answering guiding questions and documenting design decisions (Gama et al., 2019). There is evidence to suggest that imposing a design-focused structure on hackathons encourages effective designing (Buttfield-Addison et al., 2016; Soligno et al., 2015).

1.4 Summary and study objectives

Over the last two decades, hackathons and hackathon-like events have seen an impressive growth and rise in popularity. While not always explicitly promoted as such, hackathons provide participants with exposure to, and experience in, design (Artiles & Wallace, 2013; Komssi et al., 2015). However, the structure of hackathons themselves – in particular the extreme time pressure under which they place participants - constrains design activity in unique ways that may not be representative of or generalizable to the authentic design activity that is typically studied using observations of (expert) designers in field studies. The limited time available may prevent long periods of problem analysis and design iteration, presenting a conflict between the work required and the time available. The hackathon design process may differ from processes followed in typical design projects in order to resolve this conflict; however, a shared understanding of how this setting affects design behaviour and outcomes has not yet emerged.

Hackathon events are centered on the activity of designing, yet the design research community has been slow to recognize the opportunities that these settings offer for studying design. The existing understanding of the characteristics of the design processes followed by hackathon participants is limited, pieced together from studies with objectives to report on a hackathon (e.g., Alamari et al., (2019)), outline individual experiences (e.g., Aryana et al., (2019)), or share methods for adapting hackathons to new settings (e.g., Flores et al., (2018)). Existing literature often consists of experience reports or studies of a singular event, or within a specific domain (Kollwitz & Dinter, 2019; Raatikainen et al., 2013). The one known attempt to synthesize this knowledge is a recent literature review by Kollwitz and Dinter (2019), who propose a taxonomy of hackathons. However, their taxonomy focusses on how hackathons are/ought to be organized, and not on describing/understanding how hackers design.

There is a need for a comprehensive, focused study on design at hackathons. The work presented in this thesis aims to address gaps in the existing research, specifically seeking to explore the following research questions (RQs):

RQ1: What are the characteristics of the design process followed by hackathon participants?

RQ2: How does the design process at hackathons differ from more typical design projects?

Further, hackathons are inherently a collaborative setting, where participants (often unknown to one another) form design teams and partake in a design project of short duration. Little is known about the impact that the diversity in the participant pool (in background and experience), team formation processes, and team composition have on the resulting design processes of the hackathon team. In particular, of interest is the role that previous design experience plays in how participants approach hackathons, and the role that designers play in their hackathon teams. Therefore, a third research question is also posed:

RQ3: How does team composition impact the design experience at hackathons?

In summary, hackathons present themselves as unique and authentic settings at which design activity can be studied. This chapter has provided a literature review on the hackathon phenomenon, argued their importance to design research, and presented three research questions. The rest of the thesis is structured as follows. Chapter 2 describes the methodology employed in the study. Chapter 3 presents findings in support of the first two research questions, exploring the descriptions of design at hackathons from the interview participants, and Chapter 4 presents findings to address the third research question, outlining how teams collaborate at hackathons and a common source of conflict in hackathon teams. Finally, Chapter 5 summarizes the study findings and provides a discussion of the study limitations and future research directions.

Chapter 2
Methodology

This research is a thematic analysis on transcripts from an interview study. Recruitment was open to any person who had participated in at least one hackathon, taking a "big net" approach to learning about experiences at different hackathons from participants in different disciplines. Participants were recruited via social media posts and networking channels on platforms including *Twitter, Facebook,* and *LinkedIn,* as well as through snowball sampling. In total, 16 interviews, each 45 to 60 minutes in length, were conducted remotely between spring 2020 and winter 2021. Participants were located in Canada, the United States, and India.

Table 2 presents a comprehensive overview of the 16 study participants. Thirteen participants presented as female, and three presented as male. While the gender demographics of hackathon participants vary between events, it was found than an average of 23% of participants are women (Kos, 2019a), indicating that the gender distribution of the interview study sample is not representative of the wider distribution of hackathon participants, The study participants had attended as few as one and as many as 13 hackathons, for a combined total of 65 hackathons, each ranging from 24 to 72 hours in length. The participants' background is informed by two categories: their academic background and their professional experience. As P8 explained, the attendees at hackathons "tend to be students because they have the most free time" so, it is unsurprising that 11 participants were undergraduate students at the time of their interview. The participants' highest level of completed or in-progress education was a master's degree. Their academic backgrounds varied: five had earned or where in the processes of earning degrees in engineering, four in computer science, and three in art and design. The remaining six participants had completed interdisciplinary degrees, with two having earned master's degrees in design. Participants had an average of approximately 2.2 years of working experience in either design or software development roles. Nine study participants had experience in design, particularly User-Experience (UX) design. These participants were prioritized in recruitment because of their design knowledge and ability to speak about the design process more thoroughly than the developer participants.

The systematic literature review was completed prior to beginning the interviews; thus, the interview questions aimed to confirm what was learned from the literature, that is, the patterns of design activity, and explore how the unique characteristics of hackathons impacted those activities.

Table 2: Study participant information

Participant ID	Highest education completed or in progress	Education Disciplinary Family	Current job status	Professional experience (years)	Professional Disciplinary Family	Hackathons attended	Focus of attended hackathon(s)	Average length of event (hours)	Size of hackathon team	Self-identified hackathon role
P1	Undergraduate	Engineering	Student	0-1		8	Software development	48	4	Developer
P2	Undergraduate	Interdisciplinary	Professional	7-8	Software Engineering	3	Various (healthcare, community engagement, company-internal)	24-48	3-4	UX Designer
P3	Undergraduate	Interdisciplinary	Student	0-1		1	Social change	36	3	Developer
P4	Undergraduate	Engineering	Student	1-2		2	Tech-centric and company-internal	36	4	Developer
P5	Undergraduate	Interdisciplinary	Professional	6	Design	4	Various (healthcare, social impact, tech)	24-48	3-4	UX Designer
P6	Undergraduate	Arts	Student	0-1		13	Various (blockchains, mental health, digital product development)	24-48	3-4	UX/UI Designer
P7	Undergraduate	Interdisciplinary	Professional	2	Design	1	Healthcare	60	3	UX Designer
P8	Undergraduate	Computer Science	Student	0-1		2	Civic hackathon (student focussed)	24	4	Developer with business perspective
P9	Undergraduate	Liberal Arts and Computer Science	Student	0-1		8	Tech-centric, virtual	24-72	4	Front-end developer
P10	Undergraduate	Computer Science	Student	0-1		6	Tech-centric, education, healthcare	24	4	UX developer
P11	Master's	Interdisciplinary, Interactive Arts and Technology	Professional	5	Design	1	Community engagement	48	4	Designer
P12	Undergraduate	Engineering	Student	0-1		1	Tech-centric	48	4	Designer

P13	Undergraduate	Computer Science	Student	0-1		5	Various (healthcare, social impact, tech, company-internal. female-only)	36	4	Designer, researcher
P14	Master's	Interdisciplinary, Design	Professional	8	Design	6	Various (healthcare, community engagement, hardware, open data)	48-72	4-5 (12)	Designer, convener, business strategist, generalist, facilitator
P15	Undergraduate	Engineering	Student	0-1		1	Open-data, remote learning, Canadian culture	24	2	UI designer
P16	Undergraduate	Engineering	Student	0-1		3	Tech-centric, female-only	36-48	3-4	Business strategist

Questions initially emphasized participants' expertise and explored the extent of the breaks they took; however, these lines of questioning were quickly broadened as the interview participants revealed more interesting insights about their experiences at hackathons. The hackathon design process was found to be more intricate and subjective, necessitating a discussion with every participant to understand their decision making at the events. Further, the participants' existing knowledge and experience were explored to understand their perspective and how that shapes their understanding of design, and thus, design at hackathons. Finally, the interviews emphasized collaboration, a line of questioning not initially included in the interview questions but explored in 12 interviews.

The interviews were semi-structured. Participants were posed a list of prepared questions (Appendix B) as well as questions that arose during the interviews. The prepared questions were initially kept broad and supported the exploration of the first research question. As more was learned about the hackathon experience, questions were added to further understand details on design at hackathons. The interviews began with a set of general demographic and background questions related to the participants' domain of expertise and experience participating in hackathons, such as, "how many hackathons have you participated in?", "why did you attend the hackathon(s)", and "what role did you take in your team?" Participants were then asked questions about the activity of design at hackathons, beginning with the question, "define 'design' as you understand it" before asking them to describe their design process at hackathons and compare the experience to other, more typical, design projects. As the interviews were semi-structured, more questions were asked during the interview than initially prepared. These questions were primarily follow-up questions asked to clarify points, and prompts to elicit more details about participants' experiences. Some of these questions arose in one interview, but others were brought up in future interviews to either confirm or challenge a previous participant's perspective, as was the case with questions exploring collaboration at hackathons. In general, participants were able to recall a high-level of detail about their experiences, and often depended on examples to communicate their points.

The interview process began with four pilot interviews. The purpose of these interviews was to test the interview questions and narrow the focus of future interviews. Detailed notes were kept for these interviews. After the study received ethics clearance from the University of Waterloo's Office of Research Ethics, the remaining 12 interviews were recorded and transcribed. All interviews were hosted on *Microsoft Teams*, a video conferencing platform with the ability to generate transcripts. The transcripts were manually cleaned – removing the metadata, adjusting format, adding speaker information, and confirming the correctness of the written transcript with the interview recording – in preparation for analysis.

The transcripts of the interviews then underwent a thematic analysis, which is a widely used qualitative analysis method for identifying patterns within data (Boyatzis, 1998). Since one of the main objectives of this research is to present an overview of the hackathon design process from a set of descriptions, thematic analysis was a suitable method for extracting themes across the dataset. The thematic analysis followed the guidelines in Braun and Clarke (2006). The coding process was completed using *Dedoose,* a software used for analyzing qualitative data. A combination of theoretical and inductive coding approaches were employed. A theoretical coding approach means the process is analyst-driven and coded for specific research questions (Braun and Clarke, 2006). The theoretical codes align with the interview questions, as these codes grasp the meaning of the questions and objectives of the interviews. Inductive coding is the process of coding the data without fitting the excerpts into the existing structured research objectives, but rather, identifying codes linked to the data (Patton, 1990). The inductive codes were derived based on what was learned from the dataset, encompassing surprising findings and unplanned discussions. The analysis was completed at the latent level, that is, the analysis goes beyond the semantic content of the data to examine the underlying ideas (Braun and Clarke, 2006). The coding process began with 10 codes from interview questions; for example, *hackathon role* is a code that corresponds directly to the topic of the question, "what was your role in your team". As the transcripts were read, more codes were added as patterns in the data were identified. This process was completed by the thesis author with a secondary coder reviewing the codes after three transcripts and engaging in a discussion on emergent patterns. All 16 transcripts were coded, resulting in 90 codes on 684 excerpts.

As the unit of analysis in thematic analysis is *themes* rather than *codes,* where the themes are classifications or groupings of the codes (Braun & Clarke, 2006). This process involved considering each code and organizing them such that similar codes were clustered together. This clustering required iteration to identify logical patterns. Some codes were listed in more than one cluster; for example, the code "designer vs. developer" was clustered under the themes "Collaboration" and "Description of design at hackathons". The clusters were labelled with a theme descriptive of their contents. The first round of clustering resulted in 11 thematic clusters. These clusters are visualized in a candidate thematic map (Appendix C).

As suggested in Braun and Clarke (2006), the initial themes were reviewed and further defined. With a goal of reducing the number of themes, the themes were generalized such that the initial themes were collapsed into new, broader themes. The objective of this round of clustering was to identify the big takeaways from the codes in order to represent what was emphasized by the study participants. The resulting themes are summarized in Table 3 and the code clusters are further detailed in Appendix D and visualized in a final thematic map (Appendix E).

Table 3. Descriptions of the thematic clusters of codes

Thematic Cluster	**Description**
Typical hackathon experience	The overview of what happens at hackathons
Design at hackathons	The specifics of design activities, practices, and how they are challenged at hackathons
Collaboration	Descriptions of team dynamics, collaboration styles, and conflicts arising from a difference in design approaches
Evaluation of hackathons	Participant critical thoughts on hackathons
Miscellaneous	All other codes which did not contribute to a theme, such as participant demographics

The transcripts were revisited, and any missing excerpts were coded along the themes. The themes were then structured in such a way to best present the information in this thesis. The first two themes inform the findings presented in Chapter 3, the “Collaboration” theme is the focus of Chapter 4, and the discussion of the fourth theme, “Evaluation of hackathons” is dispersed throughout the chapter discussions.

Chapter 3
Description of design experiences at hackathons

Insights on design activity at hackathons are limited and pieced together by a few publications. The exploratory research presented in this thesis aims to present an overview of what happens at hackathons to understand how design transpires at these events. The purpose of this chapter is to give a summary of the study participants' accounts of their hackathon experiences. The findings will address the first two research questions: 1) what are the features of the design process followed by hackathon participants and 2) how does the design process differ at hackathons from more typical design activities?

When prompted to provide an overview of the design process at hackathons, participants provided varied accounts of the main stages and activities:

> "Figuring out what we want to do is the first step and then the second step is just building out like fundamental features of it all … and then we'll just honestly just execute and like keep going with the project until it's done, and once it's done or close enough to being done, then this step is just to create the *Devpost* submission and video and submit it." (P9)

> "You have your idea, and you have what it looks like, then you have to make it work, and then finally the pitch." (P6)

> "20% would be ideations, 70% would be creating the actual project, and then 10% would be wrapping things up and polishing everything." (P8)

> "Step one is probably research and refining your design, like your question. Step two is probably like UX stuff. Step 3 might be like development. Let's call Step 4 like your Design Finessing, so like that's when we came through logo and branding and stuff like that and a little more around the business strategy. Then Step 5 is figuring out how to impress the judges." (P7)

This chapter will provide a synthesis of these accounts and outline the phases of the hackathon design process and their characteristics. While there was some variation in activities, and not every participant engaged in every design phase, the subsections will chronologize the features from ideation through to the final presentation.

3.1 Ideation

The hackathon begins with team formation. Full details on the team formation process, and team composition are explored in sections 4.2 and 4.3, respectively. Once teams are formed, they begin their hackathon design process with a phase that most participants referred to simply as "ideation" and most notably characterized by team brainstorming.

Ideation may coincide with team formation. In this scenario, teams are formed either based on an idea for a project or shared interest, or based on the team's skillset:

> "[Someone will pitch] a vague idea, and then you form groups around those big ideas." (P5)

> "Once a team is formed … we discuss what we know and then what we want to build. So just assessing everyone's skillset and what we can do with that." (P9)

When teams are formed without an existing idea for a project, teams may look to the hackathon itself for inspiration. Hackathon themes, problem categories, and prizes were all identified as considerations when exploring potential problem spaces. For example, P7 attended a healthcare hackathon with a stated problem of "encouraging connecting in an aging population." Their team then brainstormed on more specific problems that fit the theme and chose the problem of connecting youth with the aging population. Similarly, hackathons may have "tracks" or "categories" that aid in problem finding. Some tracks identified in the interviews were finance, healthcare, education, and business (P9). Rather than looking to the hackathon theme, teams may look to these tracks as prompts since sponsors often inspire the tracks and provide prizes to projects in that category. For example, one participant described a hackathon track that encouraged teams to use a new Google API (P16).

Other methods for ideation include researching topics that may be of interest to team members and using design tools and techniques to aid in their team's brainstorming:

> "We would usually try to generate some ideas separately by doing research on Google or just looking into topics we found interesting.

> Once each of us had a couple of ideas we wanted to pursue we would congregate back together and talk about some of our favorite ideas and see what ideas the other members were in favor of." (P8)

> "We definitely used a lot of Post-It notes. I remember us starting ideations solo and then sharing and clustering those Post-Its to find the most popular idea." (P11)

P7 emphasized the importance of this first phase involving ideation, requirement gathering, identifying constraints, and defining the solution and its functions. They argued that this exploratory work is necessary to validate the remainder of the design process. P7 argued that ideation is the most important characteristic of the hackathon design process because, "once we had a clear idea of what we were doing, the [building phase] was actually quite straightforward."

In summary, the process of ideation varied between interview participants. Most explored potential problem areas with their team at the start of the hackathon. Identifying a project topic is a critical activity at a hackathon for teams and is often informed by team members' abilities and interests, as well as themes and tracks of the hackathon itself.

Unfortunately, the interview results do not provide sufficient insight into *what* teams are ideating exactly, from a design point of view. Taking the lens of the problem-solution co-evolution model of design (Dorst & Cross, 2001; Maher et al., 1996), it is not clear whether ideation begins in the problem or solution spaces, and what pattern the co-evolution of these two spaces exhibits given the very rapid nature of the decisions team members must make at the beginning of the hackathon with regards to the project topic. This limitation is further discussed in sections 5.2 and 5.3.

3.2 Research

Research is an activity that helps the designer thoroughly understand their chosen problem and inform the solution. Not all study participants outlined research as part of their design process at the hackathon. The discussions of research were initiated by the study participants who included research in the descriptions of their hackathon design processes. The participants who did not mention research were asked if they completed any research. One participant who did not claim to have conducted research stated that their project was "mostly based on assumptions" (P15). Others researched potential problems while few continued to research to validate their generated solutions.

The most comprehensive research work came from participants who prioritized research to inform their project. These participants emphasized the importance of thorough research in design. One participant described conducting research in order to answer the questions, “Does this problem exist? Does this actually affect people? Who is currently solving this problem and how?” (P16). Participants explained how they would conduct market research to identify similar projects, existing solutions, and any assumptions they made:

> “If a solution to our problem already exists, I will do research on what problems exactly they're solving, or if there are some parts to our problem they are not addressing … I will also see if there were some assumptions we are making that I missed, but the existing solution did not. It is also possible that my teammate made an assumption, so I will do research to find more information on that.” (P13)

> “We will search the prompt ideas and see if there's anything out there like what we're trying to do. If so, we will try to come up with something different from that, or try to modify in some way so what we do is better.” (P9)

These instances of research involved browsing the web to gather information and answer questions they may have about the project. For example, P13 wished to build a tech system using blockchain to protect medical information on organ donation in India. They searched for information on the “mechanisms that the government is working on to solve the problem” and “how the healthcare system works” to understand the problem better. P13 heavily emphasized the necessity of research at hackathons and claimed to have led their teams in this portion of the projects.

Study participants also provided insight into why the experiences of researching at a hackathon were so varied. The heightened nature of hackathons places pressure to “build a product to show the judges … so we don't have enough people or time to continue research” (P13). Therefore, there exists a trade-off between conducting thorough research and being able to produce a polished final design. P6 described how they understood the importance of conducting research and tests when designing but did not encourage these practices during hackathons because there was insufficient time. When asked to elaborate on the lack of research conducted for a hackathon project, P6 explained:

> "Research is the part that gets thrown out the window the most because it's kind of a time sink, especially when you need to give something to your engineers to do quickly so that they can start working as well and are not held back by my progress. So I think a lot of the solutions end up being not very user-centric." (P6)

The participants who encouraged their teams to conduct research (P5, P7, P11, P13, P14, P9, P16) stated that there was often resistance from their team members to complete research continuously throughout the project. Participants explained how developers, in particular, wished to begin building their project right away, skipping research altogether:

> "The developers wanted to just like get straight to the coding and then leave visualizing the workflow to the end for the pitch." (P12)

Two participants, P5 and P14, independently conducted user research after the developers on their team deemed it unnecessary and began building instead. Later, their findings were identified by their group to be helpful, stating the team's responses were "oh yeah, that's helpful" (P5) and "oh, I actually can make decisions based on that" (P14). These accounts reveal that some hackathon participants will express hesitancy to conducting research, which is perceived as an activity that limits development time, but later identify its benefits.

In summary, research is often overlooked at hackathons due to the very limited time available to complete the project. While some participants skip research altogether, others view research as central to finding and validating a problem and informing the building of the solution.

3.3 Involvement of users

In design, and particularly in user-centered design, the involvement of the user is critical. Designers are often encouraged to design *with* the user as a form of "co-creation" rather than *for* the user (Sanders & Stappers, 2008), such that the design will be best suited to the needs of the user and effectively address the user's problem. Similar to the inclusion of research in descriptions of the hackathon design process, discussions on the involvement of users were initiated by the participants when describing their work related to users at hackathons. These participants noted the importance of consulting users, and sought answers to their questions about the validity of the problem:

> "I wanted answers to, 'are we solving the right problem for the right people,' 'Will the solution be used,' and, 'does the solution address the problem?'" (P5)

> "Often, my first step would be to ask, 'what can I learn about specific users in this space and how they actually use this product' and typically, that would inform both the design and the development work." (P14)

Many interviewees explained that the nature of the hackathons significantly limits participants' motivation and ability to design with the user:

> "The narrative in tech a lot of times is you make something because the technology is there or because it is a good idea, but you don't validate that idea with people who might actually adopt that technology, and then the project will flop." (P11)

> "Design involves a lot of asking real people what they think of your product as you go along, and there's almost none of that [during a hackathon]. In my hackathon projects, we just cross our fingers that this product will work and addresses a real problem." (P10)

The ability to consult with users is limited since it is rare for the target users to attend the hackathon. Further, the time constraint of the event and the tendency for participants to work overnight prevents consultation with users, as they would likely be unavailable overnight.

P5, who took on the designer role in their hackathon team and has been a professional designer at an insurance firm for six years, emphasized designing with a user in mind:

> "I think teams tended to do better when they had somebody who was thinking about you know 'why are we doing this' and 'what are we building' and 'for whom and what are their needs?'" (P5)

P5 expressed concern for their team's idea because an authentic user did not inform it. They consider the involvement of the user in the design process as an opportunity to validate their ideas and thus wished to involve users in their hackathon project to validate the problem and solution. In an attempt to identify requirements, they asked questions to the developers in their team, including, “what benefit is it providing?” and “who's providing the data, and why would they use this?”

As previously mentioned, the ability to engage with the user(s) at a hackathon was limited due to their absence at the event, which is further complicated by the overnight working hours of the team, limits the time available to reach out to potential users. There were a few cases, however, where participants were able to connect with users. P14, who participated in a hackathon run by the local symphony, described how during the hackathon, their hackathon team attended a symphony performance offered to hackathon participants. They leveraged that opportunity to speak with attendees about their experiences to validate their idea. Another participant (P16) explained developing a survey, which was sent to friends who were in their target demographic to solidify their idea and inform their design. In an attempt to supplement what they could not learn from users due to their absence at the event, P5 consulted subject matter experts who were at the hackathon:

> “I went to talk to researchers of dementia to find out what the users really needed so that we could design our product around that.” (P5)

They highlighted how this work validated assumptions the team was making and established a well-informed foundation for their solution:

> “By asking them questions we made sure we were clear on the problem, dug into the solution a bit more deeply, and made sure that what we were doing had value.” (P5)

Two other participants intentionally defined problems for which they were part of the targeted demographic. P12 built a Fitbit app that synced music playlists to their heartbeat, and P15 designed an app to foster connectivity among students during the pandemic. By selecting problems they were experiencing, P12 and P15 could act as both the designers and the users.

P7, who described a comprehensive process of understanding and formulating the problem at hackathons, led their group through a series of user research activities, mainly persona development and journey mapping. P6 also facilitated user journey mapping. The stated purpose of this was to better understand the user for whom they were designing, identify the key touchpoints their solution had to address, and establish a set of requirements (P7). They explained their reasoning for completing such work as follows:

> "We're designing for people who aren't us; we can't design for what we think that they need. We need to design for what they need. And the only way that we can truly understand what they actually need is by doing as thorough research as we possibly can. So ideally, that's reaching out to people with lived experience with whatever issue we're trying to solve … then the next best thing that we can do is distill that into personas that represent the archetype of person that we're designing for, and every time we make a design decision, and we have to refer back to that archetype, so we know whether or not we're actually solving a conscious thought they had weather well, conscious or subconscious, but a genuine kind of concern or pain point that this person might have so." (P7)

P7 clearly outlined the reasoning for designing with the user and their inability to do so at a hackathon because, "the users aren't at the hackathon so we had to rely on other ways to learn more about the problem we thought they were experiencing." The development of user personas and revisiting these personas to inform major design decisions is a useful approach to considering the user when it is otherwise impossible to engage with the users to the extent typical in other design projects.

3.4 Building

The building stage is typically marked by prototype building and testing activities. In its simplest form, building is the "technical implementation of the project, so translating screens that are just wireframes into an actual operational prototype" (P7). Hackathon projects are typically software designs. Examples of solutions built by study participants at hackathons they had attended included: a software platform to connect youth with senior citizens to facilitate "bidirectional value exchange between a youth and somebody who would be experiencing social isolation in their older age" (P7); a "fun" online quiz that recommended users upcoming shows from the local symphony that matched the user's interest (P11); a Fitbit app that tracked the user's heart rate and played a song from the Spotify app that matched the user's heart rate (P12); and a virtual game where each user had a virtual pet to take care of and was able to interact and connect with other "pet owners"(P15).

The study participants described how their progress at this stage was achieved by delegating tasks that occur simultaneously:

> "We started by dividing the technical work and assigning each member targets and a timeline … If someone fails to meet their target, or if someone completes theirs before, they will help the other one. The group goal is to get to a minimum value product." (P13)

> "While I was working on the UI of other pages, he started coding the homepage for the website" (P15)

The building phase also encompasses consecutive and dependent tasks. For example:

> "I would start off with wireframes, just the bare bones skeleton of the design, and then that informs the engineers of the structure of the interface which is enough for them to start building. Afterwards, I would start building the design system, like colors and fonts that can be incorporated afterwards. The product can then expand from there. It's kind of like working in time with engineers like as soon as I get done, I ship it to them so they can start developing. Everything is sent in pieces." (P6)

> "One person focused on the front-end while another person created the structure of a data table for values. We would jump back and forth to the different key features of the project and created those parts of the script individually and then connected them." (P12)

P6's description shared similarities with others with respect to the development of wireframes. Sketching and wireframes were tools commonly referenced in the building process:

> "Once we decided what the front-end component was going to do we would proceed by starting to generate sketches of what that looks like. Once it seemed like everyone was generally happy with the basic layout of the front-end it was formed into a more fleshed out and comprehensive wireframe that was done on either *Canva* or *Figma*." (P8)

> "We did basic pen and paper sketches of our design." (P12)

> "After the first day we were looking at polishing off the idea, integrating any UX design and wireframes." (P14).

These descriptions suggest that the general workflow of the building stage starts with establishing wireframes and data flow before developing the back-end, followed by decisions that inform the front-end. Building at hackathons is then characterized by team members working simultaneously on dependent tasks:

> "You can't have your software developers sitting around doing nothing for the first two days and then have Thursday to kick into gear and start to do something." (P7)

P7 claimed their team would not finish a task in its entirety before the aspect of the project they were working on was given to the next member to start their dependent task. Due to the short time frame of the event, it was more efficient to work based on the available information and adjust as necessary. This strategy relied on iteration since team members had to adjust their tasks in real time based on the progress of their peers. P5 eloquently explained this phase as "an iterative loop of asking: how far have we gotten? How's it going? Did we do the thing that we intended to do? What's the next step we need to do?"

These instances of iteration suggest that some teams were testing features of their project. In traditional design projects, designs are routinely tested, but the interviews found very few mentions of testing, and the few descriptions were not of in-depth processes. Only three study participants explicitly mentioned testing their prototypes. In the first description, the participant explained how team members would check each other's work:

> "We would turn our laptops around and show everyone … We would update on progress and team members would catch if something wasn't working and help out." (P10)

This testing process involved checking functions of the individual features. The other two participants who explicitly outlined their testing process described how testing was conducted in preparation for the final presentation:

> "We tested it by running through the demo. We grabbed a couple of people who were nearby and had them try it out too. But I wouldn't say it was like a really thorough process." (P11)

> "So we tested it like three or four times to see if it worked the way we wanted it to for the pitch. Like one of us would be using [the app] while another was at the table updating the Firebase [database] and checking that it was working." (P12)

The building portion of the hackathon is the easiest to identify and often the main focus of hackathons. When asked to reflect on which phase teams dedicated the most amount of time, one participant claimed that the building portion was both the longest and most important:

> "I think that the building does have to take the most amount of time because there are elements of it you just can't speed up anymore." (P5)

Other participants also expressed a similar sentiment, explaining that the judging will not end favourably without a well-developed product. P12 offered a different opinion, explaining that they "see hackathon projects as an initial idea, and then if it's so good you get sponsors, you can develop it more after." This perspective suggests that hackathons may differ from more typical design projects in the degree of completion of the projects.

A working project was identified as crucial at online hackathons. P13 claimed that more time was dedicated to developing a pitch for an in-person hackathon, as that was their opportunity to "sell" the project; whereas at a virtual hackathon, the project is presented stand-alone and the team is not present to defend the project or explain the process. Therefore, it is important for projects to be completed and polished at online events, making the building portion of the process the most important.

3.5 Iteration

Iteration, a critical practice in design, is the repetition of design tasks (Smith & Eppinger, 1997), often intended to improve the artefact based on new information about the problem as it is learned. It is understood that iteration occurs within a design phase (e.g., iterations of prototypes in the building phase) and between design phases (e.g., revisiting the problem definition after developing prototypes). Study participants reported different levels of iteration, ranging from no iteration to a highly iterative design process.

For both P5 and P7, iteration was a fundamental and built-in practice to their design process. They claimed their projects underwent many rounds of small iterations. Their process was a cyclical process of sharing what had been learned and adjusting current designs:

> "It's pretty iterative … which is why it's so important to clarify at the beginning what we are building and why …, like we're not going to make the whole plan at the beginning and just stick to it no matter what. We bite off a chunk that seems reasonable, basically the fundamental questions or like pieces that we need to address first and test in that environment, then go from there." (P5)

> "I think it was like very rare that we came up with the right idea or made the correct decision the first time around. I would be mocking something up on my screen, we would collaboratively make suggestions like 'move this here' and 'let's change this' and then we might realize it's incompatible with something we had thought of earlier, so now I change something down the road. The whole thing was iteration and I think the final product was not even a final product, it was just the most recent iteration." (P7)

Participants also identified iteration within a phase rather than between phases. P6 claimed that the iteration that occurs in their hackathon design process must be quick and independent from other tasks because once they handed off their plans to the engineers, "it's not worth the effort to change it because they are already starting to develop it". They reported producing many sketches of a design and quickly iterating on them before making a final decision. In this case, once a decision was made, it could not be changed. This is in direct contrast with P7's approach where independent work would iteratively inform the entire design.

Not all participants claimed to have completed rounds of iteration. P10 explained that "there's like almost no iterative process" due to the time constraint, and they "wonder if the [hackathon design] process is just one round of a product development" rather than many cycles, as is typical in other design projects. Even when participants described processes that touched on the entire design process in typical projects, the necessity to do so in the 24-48 hours of the hackathon dramatically limited their ability to interact with every part of the design process thoroughly and in a highly iterative manner.

Iteration is central to agile design methods, and the connection between hackathons and agile methods was made in many interviews. P5 compared the rounds of iteration within their team to agile design sprints and outlined them as rounds of making an assumption, validating it, building, and revisiting the assumption to ensure their solution solved the problem appropriately. P9 was familiar with agile methods, such as stand-ups, and discussed their team's tendency to reconvene when they reached certain "milestones," such as when they finished larger tasks. P10 explicitly described their team's strategy as beginning each day with a discussion of outstanding tasks and developing a plan to finish them. Despite hackathons and agile methods sharing the need to quickly progress through the design process, P9 reported hackathons did not afford enough time to develop and implement agile practices, while "other projects were more structured and had a longer time frame so it was easier to host stand-ups."

3.6 Final Pitch

At the end of a design project, designers finalize remaining features of their solutions and prepare a final presentation. Hackathons are defined by competition, with top placements often awarded monetary prizes from corporate sponsors. As a result, participants dedicate significant effort to developing and practicing their final presentation, termed a pitch. Accordingly, the last activity described by the study participants was the final pitch – which usually consists of "a comprehensive pitch supported by a slide deck and a demo of the project" (P5) – to a set of judges, which often includes sponsors, who score the projects and award final prizes. Interestingly, participants described the option of selecting their judges at some hackathons by participating in extra presentations to "whichever company the app could relate to" (P12).

Table 4: Example of a hackathon's judging criteria (P15)

Judging Criteria	**Score**
Does the idea appropriately address the chosen topic?	/5
How innovative is the idea?	/5
How effective is the solution in addressing the problem?	/5
How technically challenging/impressive is the implementation?	/5
How much thought and effort are put into user experience and design?	/5
How effective is the presentation at conveying the idea and solution?	/5
Total Score	/30

The pitches are short presentations meant to communicate the project idea and hackathon outcome with time for a question-and-answer period with the judges. P15 explained the format of the final presentations as, “three minutes to pitch and then 2 minutes of questions, and we had two sessions with different groups of judges” (P15). The projects are evaluated based on a rubric, an example of which was shared by P15 (Table 4). Depending on the hackathon, there may be opportunities to practice the pitch in front of judges before the final competition: “we would try to mention the feedback we received from the mentors and fix our pitch after practicing” (P13).

Some teams place more emphasis on pitching than others, with some claiming that pitch development is the most critical phase of the hackathon. P1 stated that if the idea is pitched well, regardless of whether the team has a working model, the chances of winning are higher. They shared how in their experience, the product pitched at hackathons did not have to be finished; instead, they presented partial prototypes, sketches, and outlines of their plans to demonstrate the potential of their project. This was later confirmed by other participants, who would “present the design prototype and kind of give the judges an idea of what the 'North star' or ideal of the product would be and then present like what we have for like the technical side” (P6), meaning that as long as the solution appears to work, it does not have to work. Hence, P6 prioritized presenting the solution well over making it work:

> “Judges aren't necessarily like digging into your code and like trying to figure out if it works or not.” (P6)

P14 explained how they would consider the judging criteria when preparing their pitches:

> “Some pitch competitions are about the idea, and they don't care about the level of completion. Others are about the hardware or the functionality, and they want to grill you on the technical aspects of your idea.” (P14)

The pitch portion of the hackathon is significant to the teams for two main reasons. First, it is their opportunity to demonstrate the work they have completed, and second, it is what the teams are judged on for prizes. For these reasons, significant time is dedicated to developing the final presentation.

3.7 Time Management

While hackathons are design activities, the nature of the hackathon events challenges aspects of design found in more traditional projects. The condensed time frame causes increased levels of stress and fatigue and fewer opportunities for rest, as well as forces teams to prioritize their time, dedicating efforts to the portions of the design processes they judge to be most impactful.

Study participants mentioned creating a solution development plan with their team members to help navigate the short timeframe. This process typically began with identifying the must-have features their solution should include:

> "We will define the features that we need for the app and then prioritize those … so we kind of listed out the features and prioritized like what was most important. We specifically considered what we would pitch to the judges as well as what was easily implementable on the code side." (P6)

Team members would then delegate tasks aligned with the team members' roles. P13 explained how their team "started dividing the work to the different roles and gave each a target so they knew how they were working to the big goal," increasing clarity on individual responsibilities and the project's main objective. It was also mentioned that team members would check in with each other on their progress and help members complete their designated tasks. Teams would adjust their plans as necessary to accommodate for advances and setbacks in their projects.

Due to the notable time constraint at hackathons, participants cannot thoroughly engage with the entire design process, necessitating the prioritization of some design phases over others. Usually, this means teams are unable to engage with every phase of the design process thoroughly. One participant explained:

> "When it comes to hackathons, I also feel like I shouldn't waste time. I mean, I know it's important, but I tend to deprioritize certain stages of the design process because, in a hackathon, it's hard to do like research and testing, for example, because the work that needs to be done is within a couple of days" (P6).

P5 described the difference between hackathons and previous design experiences as follows:

> "In a hackathon, it's tough to get people to pause and actually plan because you've got so little time to do a lot of it. I think in comparison, in a design project, you spend so much time scoping what you're doing and validating that it's a problem or investigating the system that it's going to fit in and how that's all going to link together" (P5).

Another activity that is de-prioritized at hackathons is rest. Existing literature suggests that attendees grow significantly fatigued since they receive minimal sleep or breaks. To further explore the impact of limited breaks, the study participants were asked to describe any experiences of breaks they took at hackathons. Typical activities during the breaks were going for walks, sleeping, taking a shower, playing video games, and eating. Some participants, like P12, reported only taking breaks to eat meals. P7 stated that the food breaks were typically 15 minutes. Since hackathons are continuous events, the work typically continues overnight; however, many participants who did not attend with a motivation to win, "went home to sleep every night" (P9), choosing not to continue their project for 24-48 continuous hours. These participants would have the most prolonged instances of breaks reported in this study.

Breaks enable people to recover from extended periods of concentration and can serve as incubation periods (Woodworth, 1938) - a concept that is relevant to a cognitive activity such as design. While in an incubation stage in the creative process, the designer is no longer actively working on the problem (Tsenn et al., 2014; Wallas, 1926). It is theorized that the mind continues to work on the problem subconsciously. Research has found that taking a break during problem solving may lead to a moment of insight (Burkus, 2014). Additionally, incubation has been shown to help reduce design fixation and encourage the generation of a larger number and variety of ideas (Cardoso & Badke-Schaub, 2009; Tsenn et al., 2014). In traditional design projects, incubation is naturally built into the project timelines. Design occurs over days, weeks, months, or even years, meaning that periods of rest can span similar time frames. While these designers may not intentionally include incubation periods, they still receive rest from problem solving. This helps lessen the effects of fatigue and fixation. These "built-in" periods of incubation during design are absent in hackathons since the nature of the events usually necessitates working overnight. The breaks couldn't be "too long since you're very focused on building the product" (P8), and sometimes participants continued to think about their project while on a break. P13 gave reasoning to this, explaining the food at hackathons was prepared for all attendees, so the breaks for meals were often shared with other teams they did not know. Discussing projects then served as an ice breaker between teams, so participants would continue to think about and discuss their projects even while in a social setting.

Other participants stressed the importance of breaks: “It is important to spend some time outside of the current problem you're trying to solve and just hang out” (P14). Participants such as P14, along with P12, P11, P7, P15, P16, and P6, reported not only taking a break but cognitively breaking from thinking about their problem:

> “If I'm having trouble like I don't know how to program something, then it's easier to just for me like go for a walk and come back, and I'll probably do it in a shorter timeframe. I think it's very useful sometimes to take a step back and try to forget about what you're doing and then like revisit it” (P16).

Due to the time constraint at hackathon events, incubation is possible, but is more challenging and less convenient than in traditional design projects. One participant was familiar with incubation and explicitly described its benefits in their interview:

> “Incubation is possible at hackathons. I think people should go for walks, sleep, and practice good hygiene. I think simple things like stretching your legs can be excellent ways to incubate … but at hackathons this is a scaled down process.” (P11)

The intense nature of hackathon events contributes to high levels of stress and fatigue, which in turn, necessitates breaks. This study suggests that while rare, breaks do occur at hackathons, with some participants noting a (positive) impact on their work.

3.8 Summary

The objective of this chapter was to answer the research questions, 1) what are the characteristics of the design process followed by hackathon participants and 2) how does the design process at hackathons differ from more typical design activities? From the interview findings, the hackathon design process notably includes ideation, building and testing, and the final pitch, with some participants also conducting research, including actively involving users in their design, and describing instances of iteration. Interviews provided fewer examples of research and involvement of users than the ideation and building portions of the process. The lack of extensive evidence for certain activities suggests that they were completed by fewer teams at hackathons.

Iteration was one activity that appears to be minimized at hackathons. The design process is very iterative, so the claim that no iteration occurred during hackathons, or if it did, was minimal, was concerning. Upon reflecting on these discussions, an interesting pattern can be noted related to the responsibilities of the participants in their hackathon teams and their views on iteration. The study participants who self-identified as designers concluded that iteration, to some degree, occurs at hackathons. In contrast, self-identified developers did not. Further research is then needed to understand the extent to which iteration occurs at hackathons across teams with and without designers. It is possible that identifying iteration and critically discussing it is limited to those with an understanding of and experience in design. Those without design knowledge may struggle to identify iteration, even as it occurs, since the nature of the event requires the iterations to be small and quick.

The interviews revealed that to meet their event goals in the short time frame of the hackathon, teams had to strategically manage their time. Teams limited the number of breaks and prioritized certain activities more than others. Many teams struggled to understand the importance of research and instead prioritized the building of the project. Study participants explained how few team members understood the importance of dedicating time to research, and even when research was conducted, it had to be significantly limited. Thorough research was identified as a trade-off to building time, and most teams concluded that the building phase required the most amount of time.

The examples of user research included in this chapter suggest the intentional consideration of the user. The participants explained the value of consulting a user and striving to design with them, despite the built-in constraints due to the nature of hackathon events. Strategies such as consulting subject-matter experts, sending user surveys, building personas, and acting as users were all found to be effective strategies. Of course, each strategy has its trade-offs and is limited by personal biases. The first strategy, consulting subject-matter experts, helps teams identify a problem, but cannot replace the validation and detail from users. Conducting user interviews is a strong technique and popular in other design scenarios, but the time frame of hackathons likely restricted the depth at which these interviews could be conducted. The third strategy identified, user personas, is effective in framing the problem and solution for the user, but is limited by what the team knows and their personal standpoints. Finally, the strategy of defining a problem such that the team acts as the user means the user is readily available, but the team may struggle to identify personal biases.

Hackathons are highly condensed design activities and the limited time forces teams to resolve the trade-off between time for building and thoroughly exploring other aspects of the design process. Nevertheless, the interview study suggests that hackathons are design-centered events, which, due to the limits imposed by the structure of events, exhibit unique ways in which the design process is adapted. While the phases and activities of a design process can be recognized at hackathons, the extent to which teams can engage in each can differ significantly from other design situations. Therefore, an argument can be made that the unique characteristics of hackathon events differentiate them from more typical design activities. More research is needed to evaluate the extent to which hackathons are similar to and different than other design activities.

Chapter 4
Collaboration at hackathons

Hackathons are inherently collaborative events, as most participants work in a team. This chapter will explore participants' motivation for attending hackathons, how hackathon teams form, typical roles participants take in teams, how the team members' background informs the design process, and common areas of tension within hackathon teams. Ultimately, this section will answer the third research question: how does team composition impact the design experience at hackathons?

4.1 Motivation to attend hackathons

There are many appealing aspects to hackathons that could explain why people attend them; for example, to "learn, work on your project, or network with other teams and sponsors" (P13). Participants in this study offered 12 reasons for attending a hackathon; these were to learn a relevant skill (6 participants), to network (5), to win (4), to be with friends who were attending (4), to have fun (3), for the experience (3), to learn about what hackathons are (2), for free food and swag (1), to practice skills (1), to attend workshops (1), to challenge oneself (1), to travel (1), and to build their resume (1). These can be grouped into four main motivations: to learn, to network, to win, and to have fun. Participants' motivations for attending a hackathon affects how they approach the event, as it will be explored in this section.

For many participants, their main motivation for attending a hackathon was to learn. This category includes both those who attended to learn a skill and those who wanted to learn about hackathons themselves. Hackathons are very popular, so the participants were familiar with them prior to attending, but did not know what was involved:

> "I've always heard about hackathons but never participated, so I thought it would be a good opportunity to try to learn about what happens at hackathons" (P15).

Two participants wanted to help plan a hackathon, so they attended to learn more about their structure and logistics:

> "I wanted to get more acquainted with the hacking scene because I thought it would help me as an organizer for organizing the hackathon at my University." (P8)

> "I think mostly I just wanted to see how [hackathons] work. My friend who I went with had attended a hackathon before, so I learned from her how it was supposed to play out and the steps I should follow. I had no idea how hackathons work." (P12)

Other participants attended hackathons to learn a new skill. One participant explained their "motivation would probably just be to learn something new out of it. So either by building a project or just attending a speaker series or an event" (P9), and another wanted to practice the skills they were beginning to develop: "I wanted to work on a project using like my intro course skills that I learned" (P10). P14 echoed this motivation:

> "I don't get very many opportunities in my job anymore to really dig into a specific problem and take it all the way through to a solution. Usually, I'm either just doing the research or just doing the strategy. So hackathons during the last ten years of my career development were really good opportunities to flex that muscle." (P14)

The participants who wanted to learn tended to participate in more workshops than their peers. For example, P9 attended "workshops that taught technologies that I had not used before, like working with certain APIs." Two participants described attending some hackathons exclusively for the purpose of attending workshops:

> "When I just go to the event workshops it is usually when I have a busy weekend, but I still want to learn something from what a hackathon is offering. I usually see that they're hosting some pretty cool workshops that are only a few hours of my day as opposed to committing to 24 hours for project building." (P9)

> "After we looked at the schedule we saw there were so many different cool workshops, like I went to one on front-end development and one on consulting. Someone else went to one about AI for good … We decided like in terms of what we wanted to get out of the weekend it made more sense to just attend workshops." (P16)

Another participant intentionally chose a project that would require a new skill they wanted to learn because they thought the hackathon was "a good chance for me to learn Figma, and coding using HTML" (P15). Some participants viewed their hackathon project as an activity to list on their resume and discuss in interviews:

> "I needed projects on my resume, but I didn't want to spend so much time, like weeks, working on a project … So I saw [hackathons] like as an opportunity to work with a particular software and to put the project that would only take one to three days on my resume. I would have worked on that same project for like 10 weeks if not at the hackathon. So now I have a lot of projects listed on my resume." (P10)

In this view, hackathons are events which require minimal time dedication but provide participants with valuable opportunities to advance their skills.

Similarly, the participants who attended the hackathon to network prioritized meeting the sponsors and other participants with similar career ambitions. Hackathons also typically have sponsor booths for teams to visit and network, which were the primary attraction for study participants who identified their main motivation as networking:

> "[My motivation] very self-serving. I was looking for a job at the time. I thought a hackathon would be an excellent opportunity to speak to people in the industry I'm interested in. I thought I would have an opportunity to meet a fellow UX designer and maybe collaborate with one." (P7)

> "Companies sponsor hackathons so I wanted to go because I hoped it would help me get an internship." (P10)

> "For most of the time I attended to network to understand how other people my age work, and how they think about ideas and present them how they present their ideas. I wanted to demonstrate my capabilities in in front of any industry leader." (P13)

Since hackathons are a gathering space of like-minded people, it follows that it would be a valuable opportunity to meet peers and build one's network.

Some participants were motivated to attend a hackathon by the possibility of winning a prize:

> "I was trying to win" (P5)
>
> "Sometimes I'm like really focused and want [to win] a prize." (P6)
>
> "It's a more competitive hackathon, so I think most of the people attending were there to win." (P12)

Participants who wanted to win strategically aligned their projects with the judging categories:

> "It's fun to win, so we definitely tried to align ourselves with creating something that would look good for the judges." (P9)

Many sponsors of the event would award prizes to teams that used specific technologies or created projects along a particular theme. Participants would develop projects that used those technologies to qualify for the sponsor prizes:

> "It's usually easier to stick to one of the prompts from the event so you can align your project with what they're looking for. So I usually try to pick one." (P9)

The hackathon participants who approached the event aiming to win dedicated more time to building their projects and preparing their final pitch than attending workshops or sponsor booths. Whereas participants who were motivated to learn "optimized for learning, not for outcomes" (P15), participants who wanted to win, leveraged their existing knowledge to complete a project within their expertise quickly and effectively. For example, P12 chose a software project because, "the other two ideas were more hardware related and none of us a lot of hardware experience." A few participants reported how their strong motivation to win limited their opportunities to attend other activities offered at the events:

> "I was more focused on winning. We spent a lot of time actually sitting down at a table and cranking out work and occasionally going up to the mentors for help if there was something that we didn't know how to do. When I was less invested in winning, I spent a lot of time walking around, going to the social events, like game sessions and Cup stacking. I also spent a lot of time speaking to sponsors. So it was a lot more like chill than when I was focused on winning." (P6)

> "I think our more relaxed approach generated more team camaraderie but didn't necessarily lead to more fleshed out applications. I feel like generally, teams that are very competitive with most or all members focused on winning the prize will probably have tendencies to build as much of their project out and have something down on paper that they can demo or showcase to the judges as opposed to compromising the quality and the structure of the code in favour of fun activities." (P8)

> "I think for people who are wanting to win, they put in more hours or more effort into their project because they're trying to win. When if you want to learn, I think it's a lot more laid back." (P9)

Whether participants prioritize winning or learning also affects the phase of the design process they are more likely to emphasize. For example, P9 explained that "the most important part for winning, I guess, is using or like creating something that looks good and also that has a cool feature." In contrast, they said, if attending the hackathon to learn, defining the problem is most important because the topic of the project should be reflective of the learning objective.

Within the group of participants who are motivated to win a prize are also those who seek to use the hackathon setting as an opportunity develop an innovation that they can continue to work on after the hackathon:

> "There's a very, very small group of people who attend hackathons to create a product or idea that they want to make into a business. I've seen it a couple of times where they have a really strong project by the end, and I've seen people win who are trying to get their idea off the ground … but I don't think most people who attend are like this. For example, an attendee in the second year of their program who is attending multiple hackathons a year is not trying to continue their hackathon project after the event." (P5)

However, none of the study participants stated that their hackathon project continued post-event, even those projects that won. This phenomenon is often referred to as "abandonware" by the community - ideas generated at the hackathons are abandoned at the end of the event (Komssi et al., 2015).

Hackathons are unique experiences that offer short-term challenges in a fun environment. They provide participants with free food and merchandise, and many participants are young, so the prospect of staying up all night with friends is appealing. Many participants in this study explained being motivated to attend by the hackathon environment itself, which was very friendly and casual:

> "I think they are like really fun. I really love the environment because everyone there is really motivated … it's just a fun time. I like I love like actually working within these headphones and kind of just staying up late with friends and kind of goofing around and also being productive at the same time." (P6)

Those who attended for fun also participated in activities organized by the hackathons; for example, TOHacks organized a games night (TOHacks, n.d.). Others claimed that hackathons were very popular with their friends, so they wanted to attend because their friends were:

> "My team was interested in attending, so I went too." (P11)

> "My friend was applying and so I applied too." (P12)

> "I think a friend made me go to the hardware hackathon." (P14)

> "Actually, it was my friend goes there so he told me about it and that's how I heard about it." (P15)

While no study participants claimed their motivation for attending the hackathon was to impact their community, social good is often a goal of hackathons; for example, P15 attended a hackathon hosted by their local symphony to improve attendance. Therefore, participants may attend these hackathons because they are interested in the social cause. However, P5 described claimed one of their critiques of hackathons as follows:

> "Innovation hackathons sponsored by companies rarely have an outcome which benefits the social good. These companies can throw a lot of money into [the hackathon] and be like, 'look, we did something innovative,' but what did that result in? How many businesses came out of this? People made some stuff that sounds nice … and worked on projects which have a social impact, but what actually came out of it and what's the return on investment?" (P5)

Their concern was these companies invest their money, and the participants invest their time in building the project, but then do not continue the project post-event. As P14 explained, “there is a privilege in attending a hackathon,” implying that the ability to attend an event where one does not receive compensation for their work may leave out a significant portion of the population. The representativeness of participants is perhaps the most concerning limitation to hackathons. Most hackathons are extracurricular events; thus, attendees will be people who are inclined to participate in high-intensity events in their downtime. Hackathons are also attended disproportionately by males and male-identifying individuals (Richard et al., 2015).

Overall, findings from the interviews reveal four main motivations of participants and that participants were intentional with how they spent their time at the events. The short duration of hackathons render it challenging to participate in every activity available at the event while still building a project.

4.2 Formation of hackathon teams

Since hackathons are collaborative events, team formation is a critical first activity. The interviews revealed different methods by which teams form. Some participants attended hackathons with a pre-established team (P2, P5, P6, P11, P13, P14, P15). The other method of team formation was creating teams while at the hackathon, typically by sitting down at a table with strangers and asking to join their team (P5), posting on the hackathon's communication platform (typically *Slack* or *Discord*) (P9), or by participating in a speed teammate finding activity at the event (P9). A team making activity unique to hackathons involves participants pitching an idea for a project to attract team members to join their team:

> “They would give a 60 second pitch and then at the very end of all the pitches the rest of us would go and decide what project we wanted to join. If nobody joined your project idea, then you would go and find another team.” (P7)

> “Some people had an initial idea and there was a small, almost pitch-like competition on the opening night and people would join teams that way.” (P14)

Some participants described a combination of team formation methods; for example, P12 and P16 both attended their respective hackathons with one other person and joined people they met while at the event. Study participants who attended more than one hackathon reported forming teams in different ways at other events.

The team's success depends on the abilities of the individual team members. Not surprisingly, many study participants mentioned intentionally forming teams based on skillset. As P13 explained, "the first step is to have people in your team with the essential skills." These skills correlated to the typical roles at a hackathon: front-end development, back-end development, designer, and possibly business analyst. For example, P9, a developer with knowledge of front-end development, searched for teams that needed a front-end developer or sought out back-end developers to join their team. Participants may also attend the hackathon with an idea of what they want to build, but without the skills to build it, so look for team members who have the skills they lack in order to accomplish the project. This would involve "post[ing] that I'm looking for a front-end developer, back-end developer, and a database person and then wait[ing] for people to join" (P5).

Participants often strived for a diversity of subject matter knowledge in their hackathon groups. According to P8, variety of experience and knowledge is vital because "members from different backgrounds can bring different skills and experiences to the table… If there are teammates with different expertise, it is easier to delegate tasks and have all the tools necessary to finish the project." This participant's perspective is in line with prior findings that have suggested hackathons typically enable collaboration between participants with different background knowledge (Frey & Luks, 2016).

Beyond subject matter knowledge, as teams form, members also discuss interests, their motivations for attending the event, and their expectations for group behaviour. Teams often discuss time commitment, clarifying if they will be working overnight. The study participants stated that these conversations occur before advancing beyond team formation, asking, for example, "how seriously do you want to take the hackathon?" (P6) to align team goals. As has been previously discussed, participant goals influence how they approach hackathons, and the misalignment of goals between team members is an avoidable source of team conflict.

Team composition sets constraints on what the teams can accomplish. Most participants mentioned engaging in discussion with their teammates on strengths to inform the project they would work on. P6 outlined this process as follows:

> "We kind of communicated to see what our strengths are, so we knew the limits of what we can build. So, for example, if someone on the team is like really good at AI, then we'll be like maybe we can incorporate like machine learning into our project." (P6)

Overall, the study participants' accounts suggest that that serious consideration is given to team formation at hackathons. Hackathon participants engage in necessary conversations to join terms or find members, and learn about one another to inform their project direction. Teams often strived for homogeneity of motivations and interests, but heterogeneity in skills.

4.3 Roles in a hackathon team

While not every participant reported that their hackathon team formally identified roles, there were three prominent roles identified in the interviews: developer, designer, and business analyst; however, the design and business roles were not evident in every team. The division of these roles was not as strict as in typical design projects, but the participants identified with the role they had the most related experience in, and the tasks they were responsible for. Participants claimed that they would help one another and complete each other's tasks if they had the time and expertise to do so; therefore, the division of the roles was not rigid, but the identification of the three roles is a practice employed at some hackathons to guide the division of labour.

The participants' backgrounds informed their roles at the hackathon. For example, P10 was a computer science student who served as a developer in their hackathon teams and P11, who worked as a designer for six years at a design consulting firm, was the designer in their hackathon team. Of the 16 participants, six self-identified as developers, nine as designers, and three identified with a business role. While the majority of study participants did not identify as developers, this was likely due to the study objective of understanding design work at hackathons, and the snowball sampling method employed. The designer participants would share the study information with their peers; thus recruiting more designers. However, participants did claim that the developer role was the most popular role at hackathons. Every participant claimed there was at least one developer on their team, but not every participant had a designer on their team. In fact, P7, a designer, claimed to be in "a severe minority" as a designer at a hackathon. This is unsurprising considering the history of hackathons and their marketing as a tech-centric event.

The next subsections will explore in more detail the roles participants took in their hackathon teams, mainly the roles of the developer, designer, and business analyst, the responsibilities of each role, and their impact on the hackathon projects.

4.3.1 The role of the developer

The developer role usually refers to software development since most hackathons are software-building events. Knowledge of software development is arguably the most important area of expertise needed at hackathons due to the nature of the projects built. The hackathon team member(s) assuming the developer role are responsible for developing the code for the software project. There is design work involved in the developer role, primarily the design of the software programs:

> "The software engineer was handling the actual technical implementation." (P7)

> "We broke down the problem and were able to identify what we wanted to do … my teammates were stronger in coding so they took on the developer roles and worked on programming the project." (P16)

The front-end developer is responsible for coding the part of the project the user interacted with.

> "At all hackathons I've done front-end development, so coding how the user interacts with the software." (P9)

> "They had some experience with coding in HTML and CSS so they were the developer … they coded the UI." (P15)

In the case of P3, their team developed a picture-based database to assist in bridging the technological gap in the elderly population. The front-end developer was responsible for coding the website the seniors would use. The back-end developer – a role responsible for coding the functions of the project – built the database that was linked to the website.

Study participants explained that team members' prior knowledge and experience in software development informed their projects. For example, experience with a particular technology, may motivate a team to pursue a project idea that relies on that technology:

> "We chose the *Fitbit* idea because two of us had *Fitbits* and were familiar with the software. The other two ideas were hardware-related and not a lot of us had hardware experience." (P12)

For some developers, however, a motivation to learn at the hackathon may lead them to choose project ideas that force them to become familiar with new technologies:

> "We wanted to use new technology that they hadn't used before to learn about it." (P5)

Knowledge of software development is highly important to hackathon projects, so likely holds the greatest influence on project ideas. For example, P11's team was comprised primarily of designers and not developers, so their project was not highly technical because "it reflected what we as a team were capable of".

4.3.2 The role of the designer

Another prominent role in hackathon teams is that of the designer. This role was defined in various ways, likely a result of participants differing understanding of what design entails:

> "Design means a variety of things. It can be design thinking, visual design, graphic design, user interface design, which is similar but also a little bit different [than user experience design]." (P7)

To establish a shared understanding of design and the responsibilities of a designer with interview participants, participants were asked to describe their understanding of "design" to best interpret their use of the term when mentioned in descriptions of their hackathon experiences. Participant responses can be roughly categorized into two meanings of the term. First, design as art. In this definition, design encompasses the project's visual elements and often involves developing wireframes and determining the aesthetics of the build:

> "[Design is] how your product is visually … the overview of the project, not the details." (P13)

> "When I say design, I'm thinking more like visual aspects and not the software." (P15)

This interpretation of design also corresponds to the understanding of the designer role as informing the aesthetics of the project:

> "I was a UI designer … I built the *Figma* wireframes for the project" (P15)

> "I was concerned with the interface and how the front-end would be designed … I identified in the UX developer role" (P10)

The other meaning of design that emerged from participants' descriptions was design as a process:

> "It's like understanding the problem space, doing research, understanding your users, gathering your insights and understanding the area of opportunity, then you get into ideating and creating, iterating on wireframes, prototypes, etc. Then there's testing to validate the ideas that you have." (P6)

> "Solving a problem by using a set of designerly tools. Those tools involve ways to investigate the problem and understand the stakeholders and their needs to come up with creative solutions." (P11)

> "I think design in the context that I speak of it is specifically user experience design … The context that I was specifically approaching it from was a UX perspective which is understanding your audience, considering what the product is going to make somebody feel and how they're going to actually use it." (P7)

> "Human centered design means starting with the needs of the people who are actually experiencing the problem, defining that with them, and ideally co-creating solutions with them." (P14)

> "Working with different components and putting them together and giving them a function." (P12)

The designers on hackathon teams whose work aligns with this definition of design are responsible for problem validation and user research, among other features of the design processes followed for more typical projects:

> “I was my team’s designer. … I did really basic wireframes, but I tended to still do more stuff around, like figuring out what problem we're actually solving and does it make sense how we're solving it? I tried to talk to people who were actually experiencing that problem where possible, to help us base our project in reality and frame the pitching as a real world problem.” (P5)

> “As the designer, I came from a UX perspective and my main through line was how our project would actually come to fruition and who would use it.” (P7)

> “I think I was more of a designer. I helped like create like the flow for the app.” (P12)

The presence of a designer in a hackathon team helped the team identify real-world problems experienced by users:

> “The judges appreciated that you actually talked to people when you solved a problem. We didn’t build the most technically advanced solution, but the work was highly valuable because it was based on something real.” (P5)

> “I think that the essence of it is the fact that like we're designing for people who aren't us, we can't design for what we think that they need. We need to design for what they actually need. And the only way that we can truly understand what they actually need is by doing as thorough research as we possibly can” (P7).

P10, an undergraduate computer science student, stated that, “when there is a designer [in a hackathon team], there's added precautions. There are like building blocks to kind of prevent guesswork from happening.” They shared an example of a previous hackathon project which was an app that required the user to type a command; the designer in their team caught the additional detail that the command had to be typed using only English letters and neither numbers nor symbols. This prevented the case of judges typing in a number and receiving an error. In this example, the designer on the team was responsible for checking assumptions and ultimately filled gaps in knowledge, resulting in a well-informed project.

The results from this study suggest that the presence of a designer in a hackathon team leads to teams following a more intentional design process than those without designers or design expertise. While this conclusion requires further exploration on how prior design knowledge and experience impacts design behaviour at a hackathon, this study reveals the important role designers play in their hackathon teams.

4.3.3 Other hackathon roles

The third prominent role that participants may take in a hackathon team is related to business. Usually termed “business lead” or “business analyst”, the business role leads the development of the pitch and understanding of the market:

> “I'm definitely more on the business side …I was responsible for putting together the presentation, identifying the problem and how we broke down the problem to get to our more tailored problem statement. I also conducted primary research, like putting together any surveys, to get information on the problem itself and then as well tying in things about our solution and if people would use it. The also I got secondary research from doing market research on what exists that's trying to tackle this problem right now and how our solution improvement from that. And then as well, just putting together the demo. We recorded our demo video just to avoid any errors that would happen in the moment. Finally, I looked at next steps, like if this were to continue, what would this look like and what is needed beyond the hackathon to make the product viable?” (P16)

This work situates the project in a greater social context. Business skills were explained as advantageous to the group:

> “Computer science students don't necessarily have the prerequisite business knowledge to understand what people want to purchase on a daily basis. I was able to help inject that sense of practicality and help everyone work towards a goal that could maximize our utility” (P8).

Only three study participants (P8, P14, P16) listed having previously played a business-related hackathon role; of the three, P16 was the sole participant to identify as a business strategist. The remaining two included business in a list of interdisciplinary skills they brought to their teams. When participants claimed to have knowledge in more than one area, they tended to identify with the role they had the most experience in:

> "I can code a bit, but usually like my teammates have been stronger in that area, so they take that and I take the more business side of things" (P16).

One participant identified a unique role due to their history of interdisciplinary education and an understanding of both the development and design portions of the project. They have been termed a "generalist," "facilitator," and "convenor" at different hackathons but prefer convener as it is most descriptive of their role:

> "I can speak to the designers, I can speak to the coders, and I can speak to the business students, and kind of try to facilitate the dialogue, so we all move in the same direction during the hackathon." (P14)

In addition to explaining how participants' roles in hackathon teams were informed by their background experience, interview participants also highlighted the impact of hackathon experience itself. Hackathons are unique events. P6 explains two advantages of having hackathon experience:

> "I'm so used to working in the time frame like I know how to breakdown when I should have things done by. I also understand how to work with other people in that environment." (P6)

The condensed time frame and high intensity environment are rarely replicated outside a hackathon space. Therefore, how to work in that environment is valuable knowledge that can only be gained from attending hackathons. That is why hackathons that target first-time attendees (e.g., StarterHacks (StarterHacks, n.d.)), exist - these events allow novices to gain hackathon expertise.

4.4 Perceptions of design at hackathons

In typical design projects, the work involved in designing is evident and the importance of design is understood, as it is central to the project. At hackathons, however, interview participants suggested that design is not necessarily viewed as the primary activity. Instead, software development (or coding) is the primary activity since developing software is the main objective. As both development and designing are central to hackathons, it is interesting to explore how hackathon teams navigate differences in perspectives with regards to the value of these important activities.

P6, an undergraduate student studying business and digital arts, discussed the relationship between the emphasis placed on design work and its definition, explaining how at hackathons, "designing in the problem solving sense is a bit more minimized because time does not allow for much research and access to users is limited." In contrast, "much more emphasis was placed on the visual side of design," focussing on branding and aesthetics of the project (P6). P5 observed that "teams tended to do better when they had somebody who was thinking about: why are we doing this, for whom, and what are their needs?" demonstrating how they valued work that involved users, which is typical of design work. Involving users in hackathon projects was further emphasized by some hackathon events that included "consideration of users" in the judging criteria.

The study participants who identified as designers shared their thoughts on how design is included at hackathons. It was expressed that there is a "preconceived notion that in order to be a useful member (at a hackathon), you must write code" (P10), which is a skill designers may lack. The origin of hackathons as a tech-centric event targeted to software developers has created an environment where designers feel disconnected and even unwelcome:

> "I think for most people, a hackathon implies the attendee must be a developer, but meanwhile, hackathons actually like need a much broader set of skills." (P5)

P11, a professional designer, shared their decision not to attend future hackathons because they felt their work was not welcome by their team:

> "I would be really hesitant to go again as a designer because I don't think my skill set would be valued by people who only come from a development background." (P11)

This sentiment was confirmed by P9, a developer who worked with a designer on their team. Their perception of the designer's work was that "they didn't get as hands-on with the code, and so they definitely didn't put in as much time and effort as the rest of the team" (P9). Design work is perceived as less valuable than development work at hackathons.

P5, another professional designer, shared their attempt to recruit more designers to attend hackathons with the promise of learning a skill, gaining hands-on experience, and having fun. Their efforts were unsuccessful because the designers were hesitant to participate since they did not code, so did not think they would be a valuable team member. Hackathons are thus framed as a space that "doesn't feel accessible … and missing a lot of really valuable voices" (P5).

Not all participants felt their design work was perceived negatively. A few offered promising insights of positive perceptions and a move toward hackathons with greater emphasis on design work. P6 observed a progression towards increased design presence at hackathons:

> "I do definitely see more involvement of design at hackathons in general. When I was first running hackathons like two or three years ago, it was very much a technical event. Judging was very focused on technical feasibility and complexity. But I think hackathons now have added design as a judging criteria, so design is a lot more welcome at hackathons, but it's still not a focus." (P6)

P10, a developer, expressed a desire for more designers to attend hackathons because "having a designer on your team versus not makes your project look and feel different because the usability is more advanced." Finally, P14, a designer, detailed the change in the value judgement of their design work among their hackathon teammates. They first explained how their desire to push for more design activities, especially during the ideation phase, was met with a lot of resistance. P14 worked to bridge knowledge gaps in their team and conducted user interviews:

> "Often, by the end of the hackathon, I would be able to either bridge some gaps or provide some information that really helped folks and informed their direction. So, I think by the end of the hackathon, they saw the value in the role, but early on I was often met with a bit of hesitation, like why are you asking these questions?" (P14)

In summary, the interviews revealed that design work at hackathons received varying levels of emphasis. This finding is unsurprising as not all teams engaged in every design phase. When study participants who were designers worked with teams who did not value design work, they faced the extra challenge of convincing their peers on the importance of their work. These participants often expressed how they did not feel welcome at hackathons due to their lack of coding knowledge and the perception that a valuable hackathon team member should be able to code. In general, there is a lot of design at hackathons. The act of developing a solution requires significant design efforts from every team member, even the developers must design the software program. This research has identified, however, that phases of design processes, such as research and validation, are often limited at this event, and it is this design work that is perceived as less than development work.

4.5 Conflict in hackathon teams

In the typical hackathon setting, each team will be assigned a table for the duration of the hackathon. One participant, P12, described proximity of teammates throughout the duration of the hackathon project as a distinct advantage for facilitating communication in the team:

> "We were all sitting close together and if you needed to talk, you could. Being in close proximity meant we were able to communicate easily." (P12)

P12 contrasted collaboration at hackathons to that in more traditional design projects, where frequent meetings are held but work is done asynchronously, restricting the ability to engage in conversations with teammates and ask for help, while simultaneously working on the project. At a hackathon, however, all members are at one table, making it easier to talk while working, get help from the team, and collaborate synchronously.

The need to hold hackathons virtually during the COVID-19 pandemic introduced new barriers to collaboration. Teams were no longer sharing a space, and in some cases, members were in different time zones (P9). Participants described long phone calls with their teams at the beginning of the project, followed by asynchronous check-ins via communication platforms like *Slack, Discord,* and *Facebook Messenger* (P9, P13, P15). The process was typically described as follows:

> "We would really try to align ourselves to meet up at the beginning of things to just sort out our idea, meet everyone, and establish roles. We would also figure out when everyone was free to be online again and would touch base then, but for the most part we would work offline." (P9)

The synchronous connection at the beginning of the collaboration is crucial since it involves establishing group norms and formulating a project plan. The building portion of the hackathon entails more independent work, so it does not require synchronous contact.

While communication between team members is greatly facilitated by their co-location, there are still other challenges that arise due to the nature of hackathon team. Four study participants identified communication as one of the most challenging aspects of collaboration at hackathons:

> “Everything comes down to communication it seems, but I think it was the difficulties in getting alignment across the different kind of technical silos that we were working in.” (P7)

> “I think it is most difficult thing when building out the project is communication with people and making sure everyone has the right skill set. Otherwise we can’t work as a team in an effective way.” (P9)

> “I struggled with working with new people because my friend and I didn't know the other 2 two people we worked with so we had to get to know them more and understand how they work, their skills, strengths and weaknesses.” (P12)

> “The biggest challenge we faced was communication within the team.” (P13)

Collaboration at hackathons requires teams to communicate effectively but is made more difficult because of the different areas of background knowledge and short time frame, which restricts the time available to establish group norms and working relationships. The interviews found that differences in background knowledge often caused disagreements in the hackathon teams about approaches to design processes. This tension was mainly evident between developers and designers, specifically with respect to the designers’ desire to implement UX design processes.

Many participants reported a tendency of developers to want to focus solely on coding without completing thorough problem formulation, validation, or research phases:

> “I remember in that moment really feeling the divide between developers and designers because they were just talking to each other and not even acknowledging me. And I was like, ‘do we even know what we are building, why we are building this, and who it is for?’ But they were already talking about like how they were going to set up the database like at 9:00 AM the 1st morning. I'm not a technical

> person, but I'm pretty sure there were some crucial questions we still had to find the answers to that would help them when building the database." (P5)

> "It was really tough convincing the developers on the importance of doing the persona mappings because they just wanted to start building." (P7)

> "As a front-end developer, I would just kind of be designing as we go along, instead of doing all the front work of UX design" (P9).

> "The developers understood coding better and they wanted to just get straight to that and then leave [the visuals and validation] as like the last thing to do." (P12)

> "Developers, as soon as they know roughly what the idea is, want to start developing and building out the system … they would start building the functionality of the project but in the absence of any information." (P14)

This was contrasted with the desire of designers to complete thorough problem identification, formulation, and user research phases. P5 described this contradiction of approaches: "the developers just go in the corner and like build the thing" while, as the designer, P5 was conducting "[…]mini cycles of checking in, asking 'are you still going in the direction you intended?' and 'how does this relate to the pitch that we're eventually going to give". P5 reported having felt "[…] like some of my soft skills get overlooked … since it just feels like it's developers who are important".

P5 identified the most significant area of contradiction between designers and developers as occurring in the beginning phases of the process, in particular in regards to the resources given to problem identification and formulation:

> "Two things that start to happen right away. First, the technical people tend to think about their plan for all the stuff that has to be built and what's going to take a bunch of time … Meanwhile, I, and whoever else thinks more similarly, begin with thinking about 'who are we designing this for?' and make sure we're clear on the problem itself, rather than digging into the solution." (P5)

This conflict was mentioned many times, with accounts of "software developers just [wanting to] focus on trying to get things to work" (P10). The designers explained that while the functionality of the project is important, there is concern when "building the functionality in the absence of any information" (P14), which would have been the case had research been skipped. This difference in approaches, mainly the desire to begin building quickly at the beginning of the event versus dedicating time to thoroughly understanding the problem to inform the development, led to tension in design teams.

P9, a developer, explained the difference in methods followed when there was a designer on their team versus when there was not, stating how in the latter, they "would just kind of be designing as [they] go along." Little consideration was given to the question continuously emphasized by P5; that is, "who are we designing this for." P7, a working designer with an interdisciplinary educational background, revealed that when trying to explain the importance of the design activities they wished to facilitate in their team, namely persona development, the software developers struggled to understand "how the persona activity manifests itself in the end product in a tangible way." The developers questioned, "how does this impact the code that I write at the end of the day?" which is a difficult connection to explain, especially in a short time frame.

All designers who reported this conflict in approaches between them and the developers reported still completing their desired design activities, but perhaps to a lesser extent. For example, P14 proposed two rounds of ideation to their team to narrow down the problem scope but was only able to guide their team through one round before the developers chose to begin building. Nevertheless, all designers also reported the developers expressing an understanding of the value of the design processes after they were completed.

The resolution of the conflict identified in this section is crucial. Participants reported three methods of resolving conflict which arose in their teams. First, teams had honest conversations to share the reasoning for approaches and reach a compromise:

> "It was very difficult but I had to explain to the developers, in particular, why I wanted to do the persona building and facilitate the activity. Eventually, they agreed to participate, but it was challenging convincing them how the activity will help their work." (P7)

Second, teams identified a member who had interdisciplinary expertise to act in a mediator role, aiding in the communication between team members with different knowledge bases:

> "As the facilitator I can understand the designers, I can understand the coders, and I can understand the business students, and try to facilitate the dialogue so we all move in the same direction during the hackathon. I tried to resolve the fragmentation in communication." (P14)

Finally, participants reported working independently to explore the beginning phases of the design process to the extent they wished while other team members began the building of the project:

> "I tried to explain to them why I wanted to do further research but there were people who did not agree and that caused conflict in the team … so we decided to simultaneously work on the sections of the project we wanted to and trust in the work the other members were doing." (P5)

The communication between team members and the ability to understand project directions while navigating differences in opinions is not a new challenge in collaborations. However, it can be argued that the hackathon environment places more pressure on participants, resulting in higher levels of stress, fatigue, and tension between members.

4.6 Summary

This chapter attempted to answer the research question "how does team composition impact the hackathon experience?" The findings in this chapter explained participants' motivations for attending hackathons and how those impacted the design processes teams followed at the events. Team dynamics were explored, outlining the typical hackathon roles and how teams form. Finally, the value of design work was explored and ultimately identified as a point of tension in hackathon teams.

Existing knowledge in a valuable domain *and* previous hackathon experience are valuable to the team. A strong hackathon team will have members with design, development, and business knowledge who have previously participated in a hackathon. These qualifications would allow teams to have a diverse set of knowledge on which to base their project, strategies to accomplish tasks best, and experience working in a heightened environment.

Despite the advantages of a diverse knowledge set in a hackathon team, the difference in background knowledge was identified as a likely cause of tension in teams. Designers learn to emphasize understanding the problem and dedicate significant time to the beginning phases of a project. In contrast, developers are eager to begin coding. Therefore, it is unsurprising that at hackathons, an environment significantly tailored to developers, with a short timeframe constricting phases of the design process, there is a desire to begin the building phase as soon as possible.

The interviews revealed that design work was viewed as less valuable than development work at hackathons. The work a developer does is understood by the designer: while the designer may not know *how* to code, they are well aware of the importance of such work in hackathon projects. In contrast, designers often find themselves having to justify their knowledge and contribution in their hackathon team, and must assume the responsibility to convince their teams to give design work time to be completed.

A significant indicator of increased emphasis on the value of design work at hackathons is the emergence of design-centric hackathons, termed "Designathons." As explained in Artiles and Wallace (2013), "it is the goal of designathons to use interdisciplinary backgrounds of the participants and the pressure for some medium of a deliverable to force the flow of creativity and accelerate through the stages of problem identification and brainstorm" (pp. 6–7). The emergence of designathons presents opportunities for the designers previously discouraged from attending hackathons to attend a hackathon-like event. The inclusion of "design" in the title situates the event as more inclusive of design tasks and suggests that design may play a more central and rewarded role at these hackathon events.

In general, developers in hackathon teams were reported to have wanted to begin coding as soon as possible, whereas their designer peers emphasized thorough problem formulation and user research, among other features of the design processes of more typical projects. This conflict suggests that differences in background knowledge may act as both an asset to teams – in terms of diversity of thought and skill – but also a hindrance – as difference in perspective encourages different (sometimes conflicting) approaches to the work to be done at the hackathon. The resolution of this conflict is necessary for effective team functioning.

Chapter 5
Discussion

This thesis aimed to investigate the characteristics of design and collaboration at hackathons. In what follows, the main contributions and implications of this research will be discussed, followed by its limitations. Avenues for future research will then be highlighted before the conclusion of this thesis.

5.1 Contribution

Hackathons are speed design events during which participants work in groups to brainstorm ideas for projects, build solutions (usually software), and present the final pitch. They have been adapted to new settings and purposes, such as in communities (e.g., Taylor et al. (2017)), in corporations (e.g., Saravi et al. (2018)), and in educational institutions (e.g., Gama et al. (2019), Page et al. (2016), Rennick et al. (2018)), and for education, networking, and innovation (Flores et al., 2018). They are increasingly popular events, involving a large number of participants. For example, the largest hackathon in North America, *Hack the North*, hosts approximately 1500 participants annually (Hack the North, n.d.). With teams of 4 participants on average, the event results in approximately 375 projects in a singular weekend. Considering that thousands of hackathons are held every year (5,636 in 2018 (Find & Organize Hackathons Worldwide*,* n.d.)), it is likely that the scale of the number of projects worked on annually at hackathons is in the millions.

Hackathons require significant design work; yet they have been relatively unexplored in design research. Based on a comprehensive search of the literature, there have been no focused studies of design processes at hackathon, though some insight about unique characteristics of design at hackathons can be extracted from existing studies on hackathons, most of which focus on reporting on a hackathon and/or sharing methods for improving/adapting hackathons (e.g., Alamari et al. (2019), Flores et al. (2018)). The motivation for this thesis was to explore how design processes are adapted in the collaborative design setting of hackathons, by posing the following research questions:

RQ1: What are the characteristics of the design process followed by hackathon participants?

RQ2: How does the design process at hackathons differ from more typical design projects?

RQ3: How does team composition impact the design experience at hackathons?

To answer these questions, sixteen people who had previously attended at least one hackathon (for a combined total of 65) participated in semi-structured interviews. The interview questions aimed to understand the design processes participants had followed at hackathons, with emphasis on how this differed from other design activities and how the background knowledge of the participant and their team members informed these processes and resulting design.

Participants' descriptions of their experiences at hackathons provided insight on the first research question. The study found that the hackathon design process is primarily characterized by three activities: ideation, solution building, and preparing for the final pitch. Teams ideate their hackathon project either during team formation, such that teams are formed based on ideas for projects, or following a team brainstorming activity. The building phase of the project takes up the most amount of time. During this phase teams code the front- and back-ends of their software projects. The final activity - the pitch - is heavily emphasized by hackathon teams. Teams prepare slide decks, demonstrations of their projects, and a pitch for the judges in hopes of winning a prize. These three activities were detailed by every study participant, suggesting they form the foundation of the hackathon design process.

In addition to ideation, solution building, and pitching, some participants shared accounts of conducting research, considering the user in their designs, and design iteration, albeit in limited capacities. The research completed by study participants primarily involved web-based research on the identified problem to understand it and identify existing solutions. There were also descriptions of user research. Participants described consulting with stakeholders, designing user surveys, selecting a problem such that their hackathon team made up the users, and briefly discussing their project with potential users. While research and user involvement are limited due to the time constraint from a short event, involving users in the design process is further complicated due to their absence from the events. The descriptions of iteration were varied, such that some participants claimed iteration was impossible, whereas others adopted an iterative approach. Study results suggest that iteration does indeed occur at hackathons, but is more likely to be recognized by participants who are familiar with the concept. Further, iterations are small and typically within a design phase.

Typically, design processes can span many weeks, months, or years. In contrast, hackathons typically occur in a 24-48 hour period. The second research question sought to explore the effect of this highly constrained time frame on the design process and how that resulting process compares to the process followed in more traditional design projects. The short time frame of hackathons forced teams to strategically manage their time. Two main time management strategies were identified in the interviews. First, while the hackathon design process is reflective of process followed in more typical design projects, the interviews found that not every team engaged with every phase, and even those who did, were unable to do so thoroughly. Teams prioritized certain activities over others, such as building over conducting thorough research. Need finding and analysis – an important but often overlooked step by student design teams (Flus et al., 2020; Nespoli et al., 2018) – is limited at hackathons. In the hackathon setting, the ultimate goal of producing a demo-ready prototype for the judges during the pitch session pressures hackers to complete the beginning phases of the design process, notably research and validation, quickly to give more time for building and pitch development. Second, participants limited the number and length of their breaks. Since typical design project span a longer period of time than hackathons, there are built-in breaks in the design processes. At hackathons, however, the highly condensed time frame eliminates long periods of incubation, with breaks typically being for food, or short periods of rest. In fact, the interviews confirmed what was known from the literature – hackathon participants tend to work overnight to maximize the available building time.

While hackathons provide opportunities for participants to engage with design, the resulting design processes are limited in significant ways, suggesting that hackathons may be more suited as opportunities to thoroughly engage with *parts* of the design process, or *briefly* with the entire process. If hackathons emphasize parts of the design process, such as idea generation, then the end of the event could see researched and validated *ideas* for projects rather than under-researched and unvalidated end products. Similarly, organizers of a hackathon challenging participants to develop a working product could provide them with a well-defined problem, so participants' design efforts can be devoted to developing and testing solutions rather than ideating a problem. Such adaptions would be especially beneficial when considering hackathons in educational settings. This would grant students with the opportunity to experience design, while avoiding the pitfall of misrepresenting the entirety of the process.

The third research question concerned the topic of collaboration at hackathons. It asked how team composition affects the hackathon team and its design processes at the event. The study found that one of the first factors differentiating hackathon participants is their motivation for attending the hackathon: to network, to learn, to win, and to have fun. These motivations align with what the literature outlined as the common goals of hackathons: to network, to learn, and to produce new artefacts (Nolte et al., 2020). The competitive nature of the event naturally also promotes a motivation to win for some participants. The interview participants explained how these motivations (along with their skillset and interests) played a role how the team approached their hackathon experience. The experiences of study participants who wanted to network included instances of visiting sponsor booths and dedicating time to meeting new people at the event. Those who attended hackathons to learn attended workshops, whereas those who wanted to win dedicated increased efforts to building projects rather than attending other activities. Finally, participants who wanted to have fun would attend the events with their friends and participate in extra activities at the hackathon. Participants' motivations also play a role in team formation – goal alignment between team members is important and is established in the early stages of the hackathon.

The study also revealed that typically participants may take on one of three roles in their hackathon teams: developer, designer, and business analyst, in descending order of commonality. The developer role is responsible for the technical implementations of the project, coding the front- and back-ends of a software project. The designer role was found to have some variation in responsibilities, likely corresponding to the team's understanding of design. Designers' responsibilities range from the establishing the aesthetic portions of the project to facilitating the design process, including research and validation. Interestingly, the study participants who had previous design knowledge, and therefore acted as the designers of their group, shared the most in-depth descriptions of research, validation, iteration, and incubation. This is likely since these participants were familiar with these practices in other design projects, so attempted to emulate these processes at hackathons. Finally, the business-related role is primarily responsible for developing the pitch.

The study also found that design work is often met with a lot of hesitancy at hackathons, in particular from developers. Developers wish to prioritize the building of the solution, and often jump right from ideating a project topic to building the solution. In contrast, the designers want to prioritize the beginning phases of the design process. This conflict reveals that design work is less valued at hackathons than development work, despite participants from both design and development backgrounds stating its value. As a result, while the developer role is well understood and appreciated at hackathons, designers often have to convey and justify the importance of their contributions. The designers are then not only responsible for their design work, but also educating their team on the importance of it, adding extra challenges to their collaboration. The conflict revealed between developers and designers at hackathons is an interesting and novel finding of this research.

5.2 Study limitations

This thesis is subject to the methodological limitations of interview studies. First, while the findings were informed by 16 participants from Canada, the United States, and India, who had collectively participated in 65 hackathons, the sample size is still small. The small study population size threatens the extent to which the study population is representative of the entire hackathon population, and the generalizability of its findings. The small sample size is a result of the chosen methodology, as interview studies are highly labour intensive and time consuming. In an attempt to lessen the impact of this limitation, recruitment ended once the findings were saturated, meaning the interviews were no longer resulting in new findings. Second, the researcher is involved in interviewing, so the outcomes may be altered by the biases of the researcher. The ways the questions are asked and general presence of the researcher may impact what the participant shares – an occurrence termed the moderator effect (Babbie & Roberts, 2018, p. 303). Third, the methodology required participants to rely on their memory of experiences. Remembering is an imaginative reconstruction of a past experience in relation to attitudes which affect one's ability to recall something exactly as it occurred (Bartlett, 1932). As a result, memories are subjected to systematic biases (Levine & Safer, 2002), calling into question the reliability of the data. Recall bias may alter the findings such that they do not accurately reflect the exact occurrences of design at hackathons due to the limitations of participants' memories. Further, the work presented in this thesis is only as comprehensive as the knowledge of study participants. The findings are based on the retelling of their situated experiences, and may not be representative of the typical hackathon experience.

Another limitation of the study is its broad scope. The review of the literature revealed a lack of focused previous studies on design at hackathons, which raised many questions about the characteristics of collaborative design processes in that setting. Little was known about design at hackathons prior to this study, so the interviews aimed to achieve a baseline understanding. The research was exploratory, and as such, the interview questions attempted to shed light on participants' entire experience at hackathons, from their motivations to attend these events, to the main design phases experienced, to the nature of collaboration in hackathon teams. This approach had the disadvantage that many interesting aspects of designing at hackathons were not investigated in sufficient depth. For example, as outlined in section 3.1, while "ideation" was identified by all participants as the first important phase in the design process at hackathons, the interviews did not shed sufficient light into what this stage entailed, especially in cases when participants were not following one of the problem prompts presented by hackathon organizers or sponsors. A question arises as to what exactly participants are "ideating", and how teams move between problem and solution spaces in the early stages of the hackathon. Nevertheless, while the broad scope of the interviews limited in-depth understanding of the characteristics of designing at hackathons, especially participants' design cognition during the event, it also had the advantage of providing a number of surprising findings- in particular as they relate to the nature of collaboration between designers and developers at hackathons – which were not previously explored in the literature and not initially targeted by the interviews. The study findings build a foundation on which future, more focused, studies of designing at hackathons can be built.

Another limitation is the composition of the study population. The study population is comprised of majority female-identifying individuals and participants who self-identified as designers. In contrast, the typical composition of hackathon attendees is majority males and developers (Kos, 2019a). The study population is then not representative of the typical hackathon population, limiting the generalizability of the study findings.. Further consideration is given to the "uneven" distribution of experience among participants identifying as designers and developers. While four professional designers participated in the study, no professional developers did – all participants who self-reported having taken on the developer role in their hackathon teams were undergraduate students. Overarching patterns in the accounts of experiences in both subsets of the population were identified, suggesting that despite differences in backgrounds and experience, the participants shared similar experiences at hackathon events. However, participants with professional experience were able to better articulate their experience at hackathons and more effectively contrast it to other design projects in their professional practice. In contrast, the student participants had difficulties drawing conclusions beyond surface-level descriptions of their experiences. The difference in levels of expertise between the designer and developer participants may have biased the findings; one can speculate that experienced developers may have offered different perspectives to contrast those of the inexperienced developers reported in this study.

Finally, the employed method for analysis, thematic analysis, is inherently subjective because the analysis is dependent on the dataset and coding scheme. The themes in the dataset were identified by the student researcher and are what that researcher found interesting. If this study were to be repeated by a different researcher with the same dataset, different themes may be identified. While thematic analysis is highly flexible, it can be inconsistent. An inter-rater reliability check was unable to be performed for this study because only one researcher completed the coding, but to navigate this limitation, the themes were discussed at length among the two researchers who attended the interviews and the steps outlined in Braun and Clarke (2006) were followed.

5.3 Future research directions

As hackathons become increasingly popular, there are more opportunities to conduct design research in this setting. Hackathons are hosted frequently, by many participants, and are short-term, making them a readily-available source of rich data for interesting research with a short-term investment. Olesen and Halskov (2020) differentiate between two categories of hackathon-related research: research *with* hackathons and research *on* hackathons. Research with hackathons involves using hackathons as part of the research approach. For example, the research may use hackathons as an example or means of testing some approach. On the other hand, research on hackathons is research where hackathons are the focus. The research presented in this thesis most aligns with research *on* hackathons. The objective was to understand design at hackathons, where hackathons were the focus of the research and not a means to a different purpose. This section will explore potential future research directions at hackathons.

An identified limitation of this research was the chosen methodology – an interview study. While this method was effective in exploring the nature of designing and collaboration at hackathons, it was not suitable for shedding in-depth insight on participants' design cognition at various stages in their design process, such as for example in the "ideation" stage, as previously discussed in section 5.2. The interviews provided only a surface-level account of this stage, establishing a baseline understanding of how teams decide on a hackathon project. An alternative methodology, standard for studying design cognition, is protocol analysis (Ericsson & Simon, 1984). Verbal protocol analysis, while infeasible for studying the entire hackathon design process because it is labour-intensive and impractical in long, slowly evolving design processes and with large quantities of data (Goldschmidt & Weil, 1998), can be employed for a focused study on portions of the process, such as ideation. An alternative method to consider is autoethnography, a research approach in which a research analyzes their own personal experience (Ellis et al., 2010). In the context of this research, the approach would involve the study of a design researcher's own experience participating in a hackathon as a participant. Such an approach would allow thorough reflections on both the individual portions of the hackathon design process, and the hackathon experience more generally.

Another potential research direction is on the type of design thinking employed by hackathon participants. According to the widely accepted dual-process theory (Kahneman, 2011), there are two types of thought: fast, intuitive thinking (type 1), and slow, analytical thinking (type 2). Recently, Kannengiesser and Gero (2019) mapped the dual-process theory onto design thinking, what they call fast and slow designing. Experienced designers use more type 1 thinking, or fast design; they can more quickly transform requirements into design solutions (Hurst, Nespoli, et al., 2019; Kannengiesser & Gero, 2019) using their prior "canned" designs, or "design types" (Schön, 1988). Novice designers also exhibit fast design behaviour; however, their ability to rely on past designs is limited. Progressing from an ill-defined design problem to a final solution is dependent on the designer's ability to manage the "inherent 'uncertainty' that pervades real-world design problems" (Ball & Christensen, 2019, p. 36). The atypical setting of a hackathon (dramatically increased time pressure, or a very ill-defined problem statement that is revealed at the hackathon, for example) adds new sources of uncertainty for even experienced designers. This uncertainty would require an increased need for slow design. Yet, the added time pressure of a hackathon would suggest increased occurrences of fast design. Time pressure is not necessarily a unique factor of a hackathon, as most, if not all, design tasks have a deadline. However, while 24 total hours to design may not be considered a short design time frame, it is so when the 24 hours are condensed into one day, rather than over an extended period. The requirement to progress through the design process quickly and continuously may suggest an increased inclination for fast design. Thus, further research is needed to understand how hackathon participants navigate the demand for slow design in a fast-paced setting.

Hackathons are attended by hundreds of participants, are lengthy, and occur in loud and difficult to control settings, making protocol analysis, especially verbal protocol analysis, potentially infeasible. It is thus necessary for new methods to be developed that can study design cognition “in-situ” at hackathons. The inherent large quantity of data generated at hackathons - for example, question and answer in text-based participant-mentor help channels, final project descriptions, judging criteria, and scores – point to opportunities to take new data-driven approaches such as text mining and natural language processing. Combined with more traditional protocol analysis approaches, such as the Function-Behaviour-Structure ontology (Gero & Kannengiesser, 2014) or linkography (Goldschmidt, 2014), the methods may allow for more efficient data collection and analysis in the challenging in-situ environments of hackathons. Further exploration into data-driven methodologies and how they may need to be adapted to suit a study on hackathons is needed.

The research presented in this thesis can also motivate future studies on collaboration at hackathons. More exploration is needed into the identified conflict between the designers and developers. One question that arises is whether this conflict was emphasized in this research due to the proportion of designers in the study population and if the conflict is isolated to designers specializing in certain areas, like UX design, or perhaps due to the designers having professional experience, thus wanting to enforce their typical process in an atypical setting. Future research on how the *level* of expertise impacts the hackathon experience is also needed. An individual can have different levels of expertise in various skills (Dreyfus & Dreyfus, 1980); for example, a designer can be an expert in product design but a novice in web design. While this thesis has explored the impact of differences in participants' backgrounds in terms of *area* of expertise, it failed to investigate the impacts of levels of expertise, for example, how the hackathon experiences of student participants compared to those of professionals. While hackathons attract primarily undergraduate students, it is not uncommon for working professional to also participate, as was the case with some of this study's participants. Students have limited knowledge and experience compared to working professionals, and as design novices (Crismond & Adams, 2012), likely exhibit different behaviours at hackathons compared to more experienced participants. Future studies could investigate the role the level of expertise impacts how participants approach hackathons, and their design activity in their hackathon teams.

A significant research opportunity lies in leveraging alternative formats of hackathons for design research - for example, online hackathons. These hackathons function similarly to in-person hackathons, but with increased dependency on virtual platforms for communication and collaboration between participants and event staff and mentors, and between participants within teams. The study participants of this thesis informed some comparison of online and in-person hackathon events, but this was not the objective of the research. Therefore, online collaboration at hackathons is a valuable extension of this research, especially considering the increase of remote work due to the COVID-19 pandemic. The online format presents an interesting opportunity for data collection. The digital age has introduced ease to virtual collaborations. Designers have created ways to simulate physical collaborative experiences (e.g., through interactive Post-it Note software (Everitt et al., 2003)) to facilitate virtual work. At the same time, the virtual and remote nature of collaboration between design team members adds a new dimension to design activity at hackathons. Asynchronous and remote work is common among distant collaborators, but compared to face-to-face settings, synchronous design activities conducted virtually may result in reduced interactions. Compared with face-to-face interaction, communication via video-conference has been found to reduce the back-and-forth between participants and increase the length of each turn (van der Kleij et al., 2009). Asynchronous collaboration has many additional challenges beyond those typical of collaborative design (Hauck, 1995). Collaborators may be in different time zones, have limited access to an internet connection, and experience limitations when building hardware and physical designs. These additional challenges are important to consider when studying data collected from virtual hackathons. Investigating virtual hackathons alongside in-person events could highlight the differences between virtual and face-to-face collaborative design.

The research presented in this thesis also has implications for design educators. The need to understand the ways in which the hackathon format alters the design process is especially important as hackathons become more widely used in educational settings (e.g., Artiles & LeVine, (2015), Page et al. (2016), Rennick et al. (2018), Gama et al. (2019)). While engineering education has typically been classroom-based with educators taking a "learn by doing" approach (Dym et al., 2005; Hurst, Rennick, et al., 2019), rarely do student have an opportunity to engage with the entire design process. The findings of this research suggest hackathons may provide an opportunity for students to engage in design in a format that is inherently engaging and attractive to their demographic. These practices cannot be a comprehensive and thorough exploration of every design phase, but the hackathon format allows for students to develop a project from inception through to final pitch. Therefore, the main findings of this research support the adaption of hackathons to curriculum, but also present new research opportunities for evaluating design learning in this format.

5.4 Conclusion

Hackathons are short-term design events during which participants collaborate in small groups to ideate and develop a design solution. The literature revealed limited existing research on design at hackathons, presenting a valuable opportunity to better understand the phenomenon from a design research lens. This study has demonstrated promising results in design research at hackathons. Primarily, hackathons are design-centered events, but the nature of the event challenges established design processes. The research found that participants, particularly those with design expertise, aim for their hackathon design processes to reflect typical processes with moderate success. However, the efforts to include design processes are often met with hesitation by developers, who lack knowledge in design and thus want to prioritize software development.

The findings in this study establish a foundation of understanding of design experiences at hackathons. The findings hold implications for those involved with hackathons, design education, and design research. While it is clear that there are limitations to design at hackathons and there are trade-offs to consider, hackathons are unique design events with rich data and promising future research potential.

Bibliography

Alamari, N., Alabdulkarim, A., & Al-Wabil, A. (2019). Accelerating Healthcare Innovation in Time-Bound Multidisciplinary Hackathons. *2nd International Conference on Computer Applications and Information Security, ICCAIS 2019*. https://doi.org/10.1109/CAIS.2019.8769574

Alkema, P. J., Levitt, S. P., & Chen, J. Y.-J. (2017). Agile and hackathons: A case study of emergent practices at the FNB codefest. *ACM International Conference Proceeding Series*. https://doi.org/10.1145/3129416.3129430

Artiles, J. A., & LeVine, K. E. (2015). Ta-da! You're a design thinker! Validating the DesignShop as a model for teaching design thinking to non-designers and achieving systemic redesign in the education system. *ASEE Annual Conference and Exposition, Conference Proceedings*, *122nd ASEE Annual Conference and Exposition: Making Value for Society*.

Artiles, J. A., & Wallace, D. R. (2013). *Borrowing From Hackathons: Overnight Designathons as a Template for Creative Idea Hubs in the Space of Hands-On Learning, Digital Learning, and Systems Re-Thinking*.

Aryana, B., Naderi, E., & Balis, G. (2019). Strategies for Empowering Collective Design. *The Design Journal*, *22*(1), 2073–2088. https://doi.org/10.1080/14606925.2019.1594931

Babbie, E., & Roberts, L. W. (2018). *Fundamentals of Social Research* (4th ed.). Nelson Education Ltd.

Ball, L. J., & Christensen, B. T. (2019). Advancing an understanding of design cognition and design metacognition: Progress and prospects. *Design Studies*, *65*, 35–59. https://doi.org/10.1016/j.destud.2019.10.003

Bartlett, F. C. (1932). A Theory of Remembering. In *Remembering: A Study in Experimental and Social Psychology*. Cambridge University Press.

Birbeck, N., Lawson, S., Morrissey, K., Rapley, T., & Olivier, P. (2017). Self harmony: Rethinking hackathons to design and critique digital technologies for those affected by self-harm. *Conference on Human Factors in Computing Systems - Proceedings*, 146–157. https://doi.org/10.1145/3025453.3025931

Boyatzis, R. E. (1998). *Transforming qualitative information: Thematic analysis and code development.* Sage.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Braune, K., Rojas, P.-D., Hofferbert, J., Valera Sosa, A., Lebedev, A., Balzer, F., Thun, S., Lieber, S., Kirchberger, V., & Poncette, A.-S. (2021). Interdisciplinary Online Hackathons as an Approach to Combat the COVID-19 Pandemic: Case Study. *Journal of Medical Internet Research*, *23*(2), e25283. https://doi.org/10.2196/25283

Briscoe, G., & Mulligan, C. (2014). *Digital Innovation: The Hackathon Phenomenon*. Creativeworks London.

Brown, T. (2008). Design Thinking. *Harvard Business Review*.

Burkus, D. (2014). The Eureka Myth. In *The Myths of Creativity*. Jossey-Bass.

Buttfield-Addison, P., Manning, J., & Nugent, T. (2016). A better recipe for game jams: Using the mechanics dynamics aesthetics framework for planning. *Proceedings of the International Conference on Game Jams, Hackathons, and Game Creation Events, GJH and GC 2016*, 30–33. https://doi.org/10.1145/2897167.2897183

Cardoso, C., & Badke-Schaub, P. (2009). *Give Design a Break? The Role of Incubation Periods During Idea Generation*. International Conference on Engineering Design. ICED'09, Stanford, CA, USA.

Carroll, J. M., & Beck, J. (2019). Co-designing platform collectivism. *CoDesign*, 15(3), 272–287. https://doi.org/10.1080/15710882.2019.1631353

Cooper, R. (2019). Design research – Its 50-year transformation. *Design Studies*, *65*, 6–17. https://doi.org/10.1016/j.destud.2019.10.002

Crismond, D. P., & Adams, R. S. (2012). The Informed Design Teaching and Learning Matrix. *Journal of Engineering Education*, *101*(4), 738–797. https://doi.org/10.1002/j.2168-9830.2012.tb01127.x

Damen, I., Xue, M., Grave, A., Brankaert, R., Chen, X., & Vos, S. (2019). Root: A multidisciplinary approach to urban health challenges with HCI. *Conference on Human Factors in Computing Systems - Proceedings*. https://doi.org/10.1145/3290607.3299051

De Oliveira, C. M. C., Canedo, E. D., Faria, H., Amaral, L. H. V., & Bonifacio, R. (2019). Improving Student's Learning and Cooperation Skills Using Coding Dojos (In the Wild!). *Proceedings - Frontiers in Education Conference, FIE*, *2018-October*. https://doi.org/10.1109/FIE.2018.8659056

Dorst, K. (2011). The core of 'design thinking' and its application. *Design Studies*, *32*(6), 521–532. https://doi.org/10.1016/j.destud.2011.07.006

Dorst, K., & Cross, N. (2001). Creativity in the design process: Co-evolution of problem–solution. *Design Studies*, *22*(5), 425–437. https://doi.org/10.1016/S0142-694X(01)00009-6

Dreyfus, S. E., & Dreyfus, H. L. (1980). *A Five-Stage Model of the Mental Activities Involved in Directed Skill Acquisition:* Defense Technical Information Center. https://doi.org/10.21236/ADA084551

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering Design Thinking, Teaching, and Learning. *Journal of Engineering Education*, *94*(1), 103–120. https://doi.org/10.1002/j.2168-9830.2005.tb00832.x

Ellis, C., Adams, T. E., & Bochner, A. P. (2010). Autoethnography: An Overview. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, 12(1), Art. 10, http://nbn-resolving.de/urn:nbn:de:0114-fqs1101108.

Ericsson, K. A., & Simon, H. A. (1984). *Protocol analysis: Verbal reports as data, revised edition*. The MIT Press.

Everitt, K. M., Klemmer, S. R., Lee, R., & Landay, J. A. (2003). Two Worlds Apart: Bridging the Gap Between Physical and Virtual Media for Distributed Design Collaboration. *NEW HORIZONS*, *5*, 8.

Ferrario, M. A., Simm, W., Newman, P., Forshaw, S., & Whittle, J. (2014). Software engineering for "social good": Integrating action research, participatory design, and agile development. *36th International Conference on Software Engineering, ICSE Companion 2014 - Proceedings*, 520–523. https://doi.org/10.1145/2591062.2591121

Filippova, A., Trainer, E., & Herbsleb, J. D. (2017). From Diversity by Numbers to Diversity as Process: Supporting Inclusiveness in Software Development Teams with Brainstorming. *Proceedings - 2017 IEEE/ACM 39th International Conference on Software Engineering, ICSE 2017*, 152–163. https://doi.org/10.1109/ICSE.2017.22

Find & Organize Hackathons Worldwide. (n.d.). Retrieved October 7, 2020, from https://www.hackathon.com:443/

Flores, M., Golob, M., Maklin, D., Herrera, M., Tucci, C., Al-Ashaab, A., Williams, L., Encinas, A., Martinez, V., Zaki, M., Sosa, L., & Pineda, K. F. (2018). How can hackathons accelerate corporate innovation? In I. Moon, G. Lee, J. Park, D. Kiritsis, & G. von Cieminski (Eds.), *Advances in Production Management Systems* (Vol. 535, pp. 167–175). Springer, Cham. https://doi.org/10.1007/978-3-319-99704-9_21

Flus, M., Rennick, C., & Hurst, A. (2020). Work in Progress: Improving Engineering Students' Need-finding Abilities. *2020 ASEE Virtual Annual Conference Content Access Proceedings*, 35649. https://doi.org/10.18260/1-2--35649

Fowler, A. (2016). Informal STEM Learning in Game Jams, Hackathons and Game Creation Events. *Proceedings of the International Conference on Game Jams, Hackathons, and Game Creation Events - GJH&GC '16*, 38–41. https://doi.org/10.1145/2897167.2897179

Frey, F. J., & Luks, M. (2016). The innovation-driven Hackathon—One means for accelerating innovation. *ACM International Conference Proceeding Series*. https://doi.org/10.1145/3011784.3011794

Gama. (2017). Preliminary Findings on Software Engineering Practices in Civic Hackathons. *Proceedings - 2017 IEEE/ACM 4th International Workshop on CrowdSourcing in Software Engineering, CSI-SE 2017*, 14–20. https://doi.org/10.1109/CSI-SE.2017.5

Gama, Alencar, B., Calegario, F., Neves, A., & Alessio, P. (2019). A Hackathon Methodology for Undergraduate Course Projects. *Proceedings - Frontiers in Education Conference, FIE*, *2018-October*. https://doi.org/10.1109/FIE.2018.8659264

Gero, J. S., & Kannengiesser, U. (2014). The Function-Behaviour-Structure Ontology of Design. In A. Chakrabarti & L. T. M. Blessing (Eds.), *An Anthology of Theories and Models of Design* (pp. 263–283). Springer London. https://doi.org/10.1007/978-1-4471-6338-1_13

Goel, V., & Pirolli, P. (1992). The structure of Design Problem Spaces. *Cognitive Science*, *16*(3), 395–429. https://doi.org/10.1207/s15516709cog1603_3

Goldschmidt, G. (2014). *Linkography: Unfolding the Design Process*. MIT Press.

Goldschmidt, G., & Weil, M. (1998). Contents and Structure in Design Reasoning. *Design Issues*, *14*(3). https://doi.org/10.2307/1511899

Hack the North. (n.d.). Retrieved June 21, 2021, from https://hackthenorth.com/

Hauck, S. (1995). Asynchronous design methodologies: An overview,. *Proceedings of the IEEE*, *83*, 69–93.

Hölttä-Otto, K., Niutanen, V., Eppinger, S., Browning, T. R., Stowe, H. M., Lampinen, R., & Rahardjo, A. (2018). Design sprint for complex system architecture analysis. *Proceedings of the ASME Design Engineering Technical Conference*, *7*. https://doi.org/10.1115/DETC2018-85774

Horton, P. A., Jordan, S. S., Weiner, S., & Lande, M. (2018). Project-based learning among engineering students during short-form hackathon events. *ASEE Annual Conference and Exposition, Conference Proceedings*.

Hurst, A., Nespoli, O. G., Abdellahi, S., & Gero, J. S. (2019). A Comparison of Design Activity of Academics and Practitioners Using the FBS Ontology: A Case Study. *Proceedings of the Design Society: International Conference on Engineering Design*, *1*(1), 1323–1332. https://doi.org/10.1017/dsi.2019.138

Hurst, A., Rennick, C., & Bedi, S. (2019). A "Lattice" Approach to Design Education: Bringing Real and Integrated Design Experience to the Classroom through Engineering Design Days. *Proceedings of the Design Society*, *1*, 429–438.

Izvalov, A., Nedilko, S., & Nedilko, V. (2017). Comparison of Game creation and engineering hackathons on the global and local levels. *ACM International Conference Proceeding Series*, 22–25. https://doi.org/10.1145/3055116.3055119

Johnson, P., & Robinson, P. (2014). Civic Hackathons: Innovation, Procurement, or Civic Engagement*? Review of Policy Research*, 31(4), 349–357. https://doi.org/10.1111/ropr.12074

Kahneman, D. (2011). *Thinking, Fast and Slow*. Anchor Canada.

Kannengiesser, U., & Gero, J. S. (2019). Design thinking, fast and slow: A framework for Kahneman's dual-system theory in design. *Design Science*, *5*, e10. https://doi.org/10.1017/dsj.2019.9

Karlsen, J., & Løvlie, A. S. (2017). 'You can dance your prototype if you like': Independent filmmakers adapting the hackathon. *Digital Creativity*, *28*(3), 224–239. https://doi.org/10.1080/14626268.2017.1351992

Knapp, J., Zeratsky, J., & Kowitz, B. (2016). *Sprint: How to solve big problems and test new ideas in just five days*. Simon and Schuster.

Kollwitz, C., & Dinter, B. (2019). What the Hack? – Towards a Taxonomy of Hackathons. In T. Hildebrandt, B. van Dongen, M. Röglinger, & J. Mendling (Eds.), *Lecture Notes in Computer Science* (Vol. 11675). Springer, Cham. https://doi.org/10.1007/978-3-030-26619-6_23

Komssi, M., Pichlis, D., Raatikainen, M., Kindstrom, K., & Jarvinen, J. (2015). What are Hackathons for? *IEEE Software*, *32*(5), 60–67. https://doi.org/10.1109/MS.2014.78

Kos, B. A. (2019a) An autoethnography of T9Hacks: "Designing a welcoming hackathon for women and nonbinary students to learn and explore computing." *Doctoral Dissertation.*

Kos, B. A. (2019b). Understanding Female-Focused Hackathon Participants' Collaboration Styles and Event Goals. *Proceedings of the International Conference on Game Jams, Hackathons and Game Creation Events 2019 - ICGJ 2019*, 1–4. https://doi.org/10.1145/3316287.3316292

Legardeur, J., Masson, D., Gardoni, M., & Pimapunsri, K. (2020). *The paradox of diversity's influence on the creative teams Lessons learned from the analysis of 14 editions of "'The 24h of innovation'" hackathon*. ISPIM Connects Bangkok, Bangkok, Thailand.

Levine, L. J., & Safer, M. A. (2002). Sources of Bias in Memory for Emotions. *Current Directions in Psychological Science*, *11*(5), 169–173. https://doi.org/10.1111/1467-8721.00193

Lewis, B. A., Parker, J., Cheng, L. W. S., & Resnick, M. (2015). UX Day Design Challenge: Hackathon to Apply Rapid Design Ideation to a Practical User Experience Challenge. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *59*, 304–306. https://doi.org/10.1177/1541931215591063

Lodato, T. J., & DiSalvo, C. (2015). Issue-oriented hackathons as material participation. *New Media and Society*, *18*(4), 539–557. https://doi.org/10.1177/1461444816629467

Maher, M. L., Poon, J., & Boulanger, S. (1996). Formalising design exploration as co-evolution: A combined gene approach. In J. Gero & F. Sudweeks (Eds.), *Advances in Formal Design Methods for CAD* (pp. 3–30). Chapman Hall.

McGowan, B. (2019). The role of the university library in creating inclusive healthcare hackathons: A case study with design-thinking processes. *IFLA Journal*, 45(3), 246–253. https://doi.org/10.1177/0340035219854214

McMahon, C. A. (2012). Reflections on diversity in design research. *Journal of Engineering Design*, *23*(8), 563–576. https://doi.org/10.1080/09544828.2012.676634

Mielikäinen, M., Angelva, J., & Tepsa, T. (2019). Hackathon as a kickstart for integrated ICT engineering. Proceedings of the 46th SEFI Annual Conference 2018: Creativity, Innovation and Entrepreneurship for Engineering Education Excellence, 1073–1080.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D., & The PRISMA Group. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med*, *6*(7). https://doi.org/10.1371/journal.pmed

Nandi, A., & Mandernach, M. (2016). Hackathons as an Informal Learning Platform. *Proceedings of the 47th ACM Technical Symposium on Computing Science Education - SIGCSE '16*, 346–351. https://doi.org/10.1145/2839509.2844590

Nespoli, O., Hurst, A., & Russell, J. (2018). *FACILITATING NEED FINDING AND PROBLEM FORMULATION DURING COOPERATIVE WORK TERMS THROUGH VIRTUAL INSTRUCTION - PILOT IMPLEMENTATION RESULTS*. 2473–2484. https://doi.org/10.21278/idc.2018.0257

Nolte, A., Pe-Than, E. P. P., Affia, A. O., Chaihirunkarn, C., Filippova, A., Kalyanasundaram, A., Angarita, M. A. M., Trainer, E., & Herbsleb, J. D. (2020). How to organize a hackathon—A planning kit. *ArXiv:2008.08025 [Cs]*. http://arxiv.org/abs/2008.08025

Olesen, J. F. (2017). Design processes in game jams: Studies of rapid design processes. *CHI PLAY 2017 Extended Abstracts - Extended Abstracts Publication of the Annual Symposium on Computer-Human Interaction in Play*, 723–726. https://doi.org/10.1145/3130859.3133226

Olesen, J. F., Hansen, N. B., & Halskov, K. (2018). Four factors informing design judgement at a hackathon. *Proceedings of the 30th Australian Conference on Computer-Human Interaction - OzCHI '18*, 473–483. https://doi.org/10.1145/3292147.3292155

Olesen, J. F., & Halskov, K. (2020). 10 Years of Research With and On Hackathons. *Proceedings of the 2020 ACM Designing Interactive Systems Conference*, 1073–1088. https://doi.org/10.1145/3357236.3395543

Page, F., Sweeney, S., Bruce, F., & Baxter, S. (2016). The use of the "hackathon" in design education: An opportunistic exploration. *Proceedings of the 18th International Conference on Engineering and Product Design Education: Design Education: Collaboration and Cross-Disciplinarity, E and PDE 2016*, 246–251.

Patton, M. Q. (1990). *Qualitative evaluation and research methods* (2nd ed.). Sage Publications, Inc.

Pe-Than, E. P. P., & Herbsleb, J. D. (2019). Understanding Hackathons for Science: Collaboration, Affordances, and Outcomes. *IConference 2019: Information in Contemporary Society*, *11420*, 27–37. https://doi.org/10.1007/978-3-030-15742-5_3

Piza, F. M. D. T., Celi, L. A., Deliberato, R. O., Bulgarelli, L., de Carvalho, F. R. T., Filho, R. R., de La Hoz, M. A. A., & Kesselheim, J. C. (2018). Assessing team effectiveness and affective learning in a datathon. *International Journal of Medical Informatics*, 112, 40–44. https://doi.org/10.1016/j.ijmedinf.2018.01.005

Porter, E., Bopp, C., Gerber, E., & Voida, A. (2017). Reappropriating Hackathons: The Production Work of the CHI4 Good Day of Service. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI '17*, 810–814. https://doi.org/10.1145/3025453.3025637

Prieto, M., Unnikrishnan, K., Keenan, C., Saetern, K. D., & Wei, W. (2019). Designing for collaborative play in new realities: A values-aligned approach. *2019 IEEE Games, Entertainment, Media Conference, GEM 2019*. https://doi.org/10.1109/GEM.2019.8811545

Raatikainen, M., Komssi, M., Dal Bianco, V., Kindstom, K., & Jarvinen, J. (2013). Industrial experiences of organizing a hackathon to assess a device-centric cloud ecosystem. *Proceedings - International Computer Software and Applications Conference*, 790–799. https://doi.org/10.1109/COMPSAC.2013.130

Rennick, C., Hulls, C., Wright, D., Milne, A. J. B., Li, E., & Bedi, S. (2018). Engineering design days: Engaging students with authentic problem-solving in an academic hackathon. *ASEE Annual Conference and Exposition, Conference Proceedings*.

Rey, S. (2017). Museomix: Lessons learned from an open creative hackathon in museums. *CEUR Workshop Proceedings*, *1861*, 24–28.

Richard, G. T., Kafai, Y. B., Adleberg, B., & Telhan, O. (2015). StitchFest: Diversifying a College Hackathon to Broaden Participation and Perceptions in Computing. *Proceedings of the 46th ACM Technical Symposium on Computer Science Education - SIGCSE '15*, 114–119. https://doi.org/10.1145/2676723.2677310

Richterich, A. (2019). Hacking events: Project development practices and technology use at hackathons. *Convergence: The International Journal of Research into New Media Technologies*, *25*(5–6), 1000–1026. https://doi.org/10.1177/1354856517709405

Rittel, H. W. J., & Webber, M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, *4*, 155–169.

Sanders, E. B.-N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. *CoDesign*, *4*(1), 5–18. https://doi.org/10.1080/15710880701875068

Safarova, B., Ledesma, E., Luhan, G., Caffey, S., & Giusti, C. (2015). Learning from Collaborative Integration The Hackathon as Design Charrette. In Martens, B and Wurzer, G and Grasl, T and Lorenz, WE and Schaffranek, R (Ed.), *ECAADE 2015: REAL TIME - EXTENDING THE REACH OF COMPUTATION*, vol 2 (pp. 233–240). Autodesk; Bentley; TU Wien, Fac Architecture & Reg Planning; ArchIng Akademie

Saravi, S., Joannou, D., Kalawsky, R. S., King, M. R. N., Marr, I., Hall, M., Wright, P. C. J., Ravindranath, R., & Hill, A. (2018). A systems engineering hackathon—A methodology involving multiple stakeholders to progress conceptual design of a complex engineered product. *IEEE Access*, *6*, 38399–38410. https://doi.org/10.1109/ACCESS.2018.2851384

Schön, D. A. (1988). Designing: Rules, types and worlds. *Design Studies*, *9*(3), 181–190.

Scott, M. J., Ghinea, G., & Hamilton, I. (2015). Promoting inclusive design practice at the Global Game Jam: A pilot evaluation. *Proceedings - Frontiers in Education Conference, FIE*. https://doi.org/10.1109/FIE.2014.7044162

Sims, C., & Johnson, H. L. (2011). *The Elements of Scrum*. Dymax.

Smith, R. P., & Eppinger, S. D. (1997). A Predictive Model of Sequential Iteration in Engineering Design. *Management Science*, *43*(8), 1104–1120.

Soligno, R., Scorza, F., Amato, F., Casas, G. L., & Murgante, B. (2015). Citizens participation in improving rural communities quality of life. *Computational Science and Its Applications -- ICCSA 2015*, *9156*. https://doi.org/10.1007/978-3-319-21407-8_52

StarterHacks. (n.d.). *StarterHacks 2020*. Retrieved October 29, 2019, from https://starterhacks.ca

Suominen, A. H., Halvari, S., & Jussila, J. (2019). World Heritagemeets Smart City in an Urban-Educational Hackathon in Rauma. *TECHNOLOGY INNOVATION MANAGEMENT REVIEW*, *9*(9), 44–53. https://doi.org/10.22215/timreview/1268

Taratukhin, V., Kupriyanov, Y. V., Welch, C., & Anikushina, V. (2018). Leveraging the tech-savvy next-generation talents and hackathon techniques to accelerate digital enterprise journey and space-related endeavors. *ASEE Annual Conference and Exposition, Conference Proceedings*.

Taylor, N., Clarke, L., & Gorkovenko, K. (2017). Community Inventor days: Scaffolding grassroots innovation with maker events. *DIS 2017 - Proceedings of the 2017 ACM Conference on Designing Interactive Systems*, 1201–1212. https://doi.org/10.1145/3064663.3064723

Taylor, N., Clarke, L., Skelly, M., & Nevay, S. (2018). Strategies for engaging communities in creating physical civic technologies. *Conference on Human Factors in Computing Systems - Proceedings*, *2018-April*. https://doi.org/10.1145/3173574.3174081

TOHacks. (n.d.). TOHacks New Design. Retrieved May 13, 2020, from https://www.tohacks.ca

Thomer, A. K., Twidale, M. B., Guo, J., & Yoder, M. J. (2016). Co-designing scientific software: Hackathons for participatory interface design. *Conference on Human Factors in Computing Systems - Proceedings*, 3219–3226. https://doi.org/10.1145/2851581.2892549

Trainer, E. H., Kalyanasundaram, A., Chaihirunkarn, C., & Herbsleb, J. D. (2016). How to Hackathon: Socio-technical Tradeoffs in Brief, Intensive Collocation. *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing - CSCW '16*, 1116–1128. https://doi.org/10.1145/2818048.2819946

Truyen, F., Taes, S., & Colangelo, C. (2017). The Europeana Space Mooc: Creative With Digital Heritage. In Chova, LG and Martinez, AL and Torres, IC (Ed.), *9TH INTERNATIONAL CONFERENCE ON EDUCATION AND NEW LEARNING TECHNOLOGIES (EDULEARN17)*.

Tsenn, J., Atilola, O., McAdams, D. A., & Linsey, J. S. (2014). The effects of time and incubation on design concept generation. *Design Studies*, *35*(5), 500–526. https://doi.org/10.1016/j.destud.2014.02.003

Uffreduzzi, M. (2017). *Hackathon as Emerging Innovation Practice: Exploring Opportunities and Challenges through 8 in-depth Case Studies*. Politecnico di Milano.

van der Kleij, R., Maarten Schraagen, J., Werkhoven, P., & De Dreu, C. K. (2009). How conversations change over time in face-to-face and video-mediated communication. *Small Group Research*, *40*(4), 355–381.

Wallas, G. (1926). *The Art of Thought*.

Woodworth, R. S. (1938). *Experimental psychology*. Holt.

Appendix A
Systematic literature review results

Table A-1 presents an overview of all reviewed publications and the hackathon(s) they study. All reviewed publications include information on design activity at a hackathon, or directly study design processes at a hackathon event. The publications varied in their motivations. A few publications aimed to propose a framework for hackathons (Johnson & Robinson, 2014; Buttfield-Addison et al., 2016; Flores et al., 2018). They either presented a pattern of design behaviour as observed at a hackathon, or a structure to be followed at a hackathon. Other motivations included identifying the purpose of hackathons (Komssi et al., 2015), studying the effectiveness of hackathon-like events in teaching design (Artiles & LeVine, 2015), and identifying potential benefits of hackathons (Carroll & Beck, 2019). A few of the reviewed publications do not aim to study design activity at hackathons, but rather to describe how hackathons are used to find solutions to complex problems; such as accelerating healthcare innovation (Alamari et al., 2019), involving citizens in rural community development (Soligno et al., 2015), and supporting diversity in software development (Filippova et al., 2017). In these cases, discussions on the design processes of participants are limited.

The first section in Table A-1 includes information on the publication: citation, subject area, and the number of hackathons included in the study. Most of the publications were sourced from journals or conference proceedings in the subject areas of computer science and engineering. Only five publications focus on more than one hackathon, whereas the rest study individual hackathons.

The second section in Table A-1 categorizes publications based on methodology employed, which spans case study (7 publications), autobiographical (5), ethnographic (5), interview/focus group (13), survey (9), and even secondary data analysis (1) approaches. For example, in one study, researchers study healthcare innovation at a hackathon by following a set of selected teams throughout the duration of the hackathon and describing the design stages followed (Alamari et al., 2019). Similarly, Taylor et al. (2017) describe the observed behaviours of participants in a series of Inventor Days as they completed various tasks to learn about a community, identify issues, and develop solutions for grassroot innovation. In the case of interviews and focus groups, hackathon participants are gathered after the event and asked key questions related to the authors' research question(s). Surveys are also typically administered to hackathon participants post-event; however, in a few cases, surveys are used as a measurement tool (for example, to assess the effectiveness of an intervention) and thus participants complete both pre- and post-event surveys (Artiles & LeVine, 2015). Finally, in at least one case, secondary data analysis is conducted on registration information to study demographic characteristics of the hackathon participants (Izvalov et al., 2017).

The third section in Table A-1 lists the topic of each hackathon under study. Five of the studied hackathons are either labelled as “game jams”, or have the aim of game development (Scott et al., 2015; Buttfield-Addison et al., 2016; Izvalov et al., 2017; Olesen, 2017; Prieto et al., 2019). Another five publications present education-oriented activities that follow the hackathon pattern (Horton et al., 2018; Rennick et al., 2018; Taratukhin et al., 2018; Gama et al., 2019; Mielikäinen et al., 2019). These hackathon-like events aim to engage students in a heightened design activity, either in-class or as an out-of-class activity, where the specific topic is related to the students’ field of study, with the prompts ranging from addressing natural disaster problems to solving mechanical engineering problems. Five publications discuss “civic hackathons” (Johnson & Robinson, 2014; Soligno et al., 2015; Gama, 2017; Taylor et al., 2017; Damen et al., 2019), meaning citizens are involved in solving problems related to their communities. Three hackathons are about healthcare (Piza et al., 2018; Alamari et al., 2019; McGowan, 2019), and another three centre around the sustainability topics of water quality (Carroll and Beck, 2019), biodiversity (Thomer et al., 2016), and ecology (Lodato & DiSalvo, 2015). Finally, one hackathon is in each of the following areas: mental health (Birbeck et al., 2017), education (Artiles & Lande, 2016), film and television (Karlsen & Løvlie, 2017), aircraft design (Saravi et al., 2018), diversity awareness (Safarova et al., 2015), museum artefact design (Rey, 2017), student life (Aryana et al., 2019), greeting card reconceptualization (Page et al., 2016), and app development and financial innovation (Frey & Luks, 2016). Also included in the third section is if design was facilitated during the event, if the event was competitive, and the targeted participant profile.

Finally, section four categorizes the purpose of the hackathons according to a classification proposed by Briscoe and Mulligan (2014). Hackathons are either “tech-centric” or “focus-centric”. Tech-centric hackathons focus on software development and can aim to improve a single application (“single-application”), a specific platform (“application-specific”), or create an application within a specific programming language (“technology-specific”). Applied (or “focus-centric”) hackathons focus on contributing to a social issue (“socially-oriented”), targeting a specific demographic (“demographic-specific”), or addressing a business objective within an organization (“company-internal”). The 39 reviewed publications describe a balance of tech- and focus-centric hackathons, with the majority being application-specific or socially-oriented.

Table A-1: An overview of the publications and hackathons included in the literature review.

Citation	Publication Subject Area	Number of hackathons	Experimental	Case study	Autobiographical	Observations	Interview/Focus group	Survey	Literature Review	Data analysis	Topic	Design facilitated?	Competetive event?	Targetted Participant	Single-application	Application-specific	Technology-specific	Socially-oriented	Demographic-specific	Company-internal
Alamari et al., 2019	Computer Science	1		✓			✓				Healthcare	✓	✓	Engineers, clinicians, programmers, designers		✓				
Artiles & LeVine, 2015	Computer Science, Engineering	3				✓		✓			Education hackathons	x	n/a	Relevant stakeholders		✓				
Aryana et al., 2019	Computer Science, Engineering	1			✓	✓					Product design	x	✓	Science, engineering, design, & business undergraduate students	✓					
Birbeck et al., 2017	Computer Science	1	✓								Mental health	x	n/a	Undergraduate and graduate students, healthcare workers, public				✓		
Buttfield-Addison et al., 2016	Computer Science	6	✓			✓					Game development	✓	n/a	Programmers, game designers, artisits	✓					
Carroll & Beck, 2019	Arts and Humanities, Computer Science, Engineering	2	✓				✓				Water quality	x	n/a	Water quality stakeholders				✓		
Damen et al., 2019	Computer Science	1		✓							Community health	x	n/a	Junior researchers from various disciplines				✓		
Fllipanova et al., 2017	Computer Science	2					✓	✓			Technical software development	✓	x	Software developers and non-technical participants		✓				
Flores et al., 2018	Business, Management & Accounting	1			✓				✓		Employee engagement	✓	✓	Employees						✓

Citation	Publication Subject Area	Number of hackathons	Experimental	Case study	Autobiographical	Observations	Interview/Focus group	Survey	Literature Review	Data analysis	Topic	Design facilitated?	Competetive event?	Targetted Participant	Single-application	Application-specific	Technology-specific	Socially-oriented	Demographic-specific	Company-internal
Frey & Luks, 2016	Computer Science	2							✓		Various	x	✓	Various						✓
Gama et al., 2019	Computer Science, Social Sciences	1					✓	✓			Course project (Computer Science)	✓	x	Computer Science and Information Systems undergraduate students	✓					
Gama, 2017	Computer Science	3						✓			Civic hackathons	x	n/a	Software engineers, designers, activists				✓		
Horton et al., 2018	Computer Science, Engineering	1				✓	✓				n/a	x	n/a	Undergraduate engineering students					✓	
Izvalov et al., 2017	Computer Science	2					✓			✓	Game development Aeronautics	x	✓	IT companies, software developers		✓				
Johnson & Robinson, 2014	Environment & Social Sciences	n/a							✓		Civic hackathons	x	n/a	n/a				✓		
Karlsen & Løvlie, 2017	Arts and Humanities	1				✓					Filmmaking	x	x	Filmmakers, artists, designers, software developers		✓				
Komssi et al., 2015	Computer Science	5							✓		Organization and business hackathon	x	✓	Employees, external companies & researchers	✓		✓			
Lodato & DiSalvo, 2015	Social Sciences	2				✓					Sustainability, ecology, food system issues	✓	✓	Developers, designers, topic experts				✓		
McGowen, 2019	Social Sciences	1	✓								Healthcare	x	x	Librarians				✓		
Mielikäinen et al., 2019	Engineering	1	✓					✓			Curricular hackathon	✓	n/a	Undergraduate ICT students					✓	
Olesen et al., 2018	Computer Science	1			✓						n/a	x	✓	Designers, programmers		✓				
Olesen, 2017	Computer Science	n/a									Game development	x	n/a	n/a			✓			

Citation	Publication Subject Area	Number of hackathons	Experimental	Case study	Autobiographical	Observations	Interview/Focus group	Survey	Literature Review	Data analysis	Topic	Design facilitated?	Competetive event?	Targetted Participant	Single-application	Application-specific	Technology-specific	Socially-oriented	Demographic-specific	Company-internal
Page et al., 2016	Computer Science	1				✓	✓				Digital products (greeting cards)	✓	n/a	Undergraduate students studying product & digital interaction design	✓					
Pe-Than & Herbsleb, 2019	Computer Science	2					✓	✓			Science Collaboration	x	x	Employees		✓				
Piza et al., 2018	Medicine	1						✓			Healthcare	x	n/a	Engineers, clinicians, data scientists			✓			
Porter et al., 2017	Computer Science	1					✓				Philanthropy	✓	n/a	n/a				✓		
Prieto et al., 2019	Computer Science, Engineering	1			✓						Game development	x	✓	Designers, software developers, artists			✓			
Raatikainen et al., 2013	Computer Science	1		✓		✓	✓				Cloud-based security software	x	x	Employees						✓
Rennick et al., 2018	Computer Science, Engineering	4				✓	✓	✓			Curricular hackathon	x	✓	Undergradate engineering students					✓	
Rey, 2017	Computer Science	1				✓					Museum creation	x	x	Graphic designers, software developers, makers, content specialists			✓			
Safarova et al., 2015	Computer Science	1	✓								Diversity awareness	✓	✓	Students of computer science, engineering, business, architecture, and design	✓	✓				
Saravi et al., 2018	Computer Science, Engineering, Materials Science	1		✓							Aircraft concepts	x	n/a	Aircraft stakeholders, partners, and engineers						✓

Citation	Publication Subject Area	Number of hackathons	Experimental	Case study	Autobiographical	Observations	Interview/Focus group	Survey	Literature Review	Data analysis	Topic	Design facilitated?	Competetive event?	Targetted Participant	Single-application	Application-specific	Technology-specific	Socially-oriented	Demographic-specific	Company-internal
Scott et al., 2015	Computer Science, Social Sciences	1						✓			Game development	x	✓	Game designers, software developers	✓					
Soligno et al., 2015	Computer Science, Social Sciences	1		✓							Technology in communities	✓	✓	University students and professors		✓				
Suominen et al., 2019	Business Management	1		✓		✓					Educational hackathon on technology in communities	x	n/a	Student groups from higher education institutions				✓		
Taratukhin et al., 2018	Computer Science, Engineering	1	✓								Natural disasters	✓	✓	Engineering and humanities students					✓	
Taylor & Clarke, 2018	Computer Science	6				✓	✓				Various	x	✓	Developers, designers, topic experts					✓	
Taylor et al., 2017	Computer Science	3	✓			✓	✓				Technology in communities	x	x	Community members, makers				✓		
Thomer et al., 2016	Computer Science	1				✓					Bioscience (Taxonomy)	x	✓	Experts in taxonomy, information science, software development		✓				

Appendix B
Interview Questions

The following is a list of interview questions approved by the University of Waterloo's Office of Research Ethics. However, since the interviews were semi-structured, more questions than included on this list were often asked, and the questions below were often altered. For example, the wording of question 8 was changed for each interview participant based on their response to questions 3 and 4. If the participant was highly experienced in design, question 8 was asked as written; but if the participant had little design experience, question 8 would follow question 9, and the participant would be asked to compare their hackathon experience with other projects they had completed, avoiding design-related terminology.

Questions 1 and 5 aimed to understand the concept of hackathon expertise. These questions were asked to establish the interview participants' own perceived level of experience , and then eventually with respect to all interview participants. Question 2 was interpreted by the study participants as their personal motivations for attending hackathons, and thus informed Section 4.1 of this thesis. Questions 3, 4, and 6 were asked to establish a baseline understanding of the participants' design experience and knowledge. As discussed in the thesis, there are many understandings of 'design', including the aesthetics of the project and the design process. These questions were asked to establish how the participant understood design in order to interpret their discussions of design at hackathons accurately. Question 7 was asked to encourage reflection from the participants on their personal standpoint and how that influenced their decision-making at the event; however, it was often difficult for them to answer this question, as they were challenged with comparing their experiences to those of others.

Depending on the flow of the conversation and the participant's design knowledge and experience, questions 8 and 9 were asked in alternating orders. These questions aimed to reveal the hackathon design process and the ways in which it was different from the design process for more typical projects. These questions prompted the longest discussion and highlighted unexpected aspects of the hackathon experience, like conflict in the teams. These findings were further supported by questions 10 and 11, which usually prompted further discussion on collaboration and conflict.

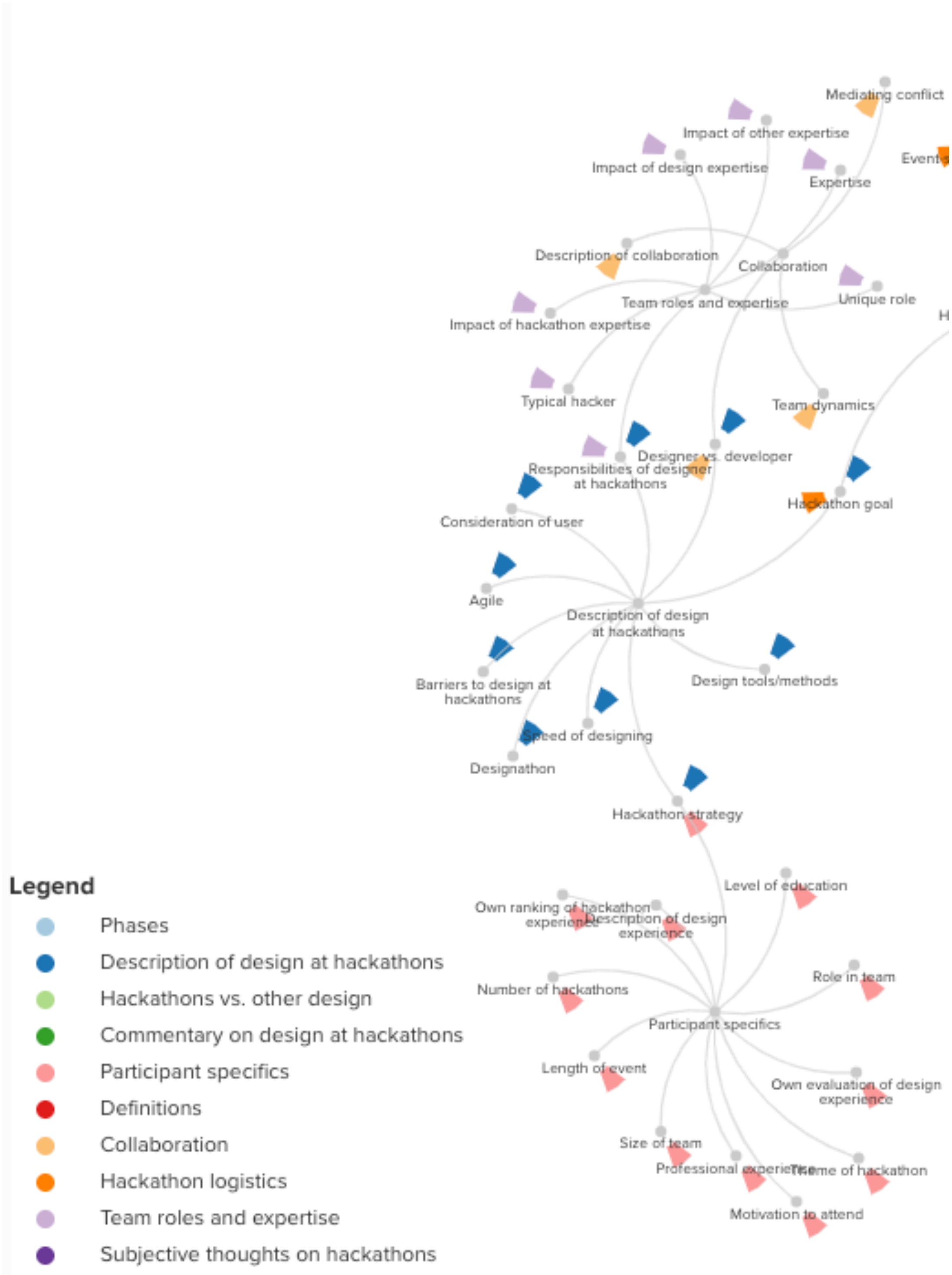
The final prepared line of questioning was on incubation at hackathons, as this was an original direction of this research. However, the findings from these questions were not as rich as previous discussions, and were found to supplement the findings on the design process, such that these questions elicited more detail on how teams managed their time appropriately.

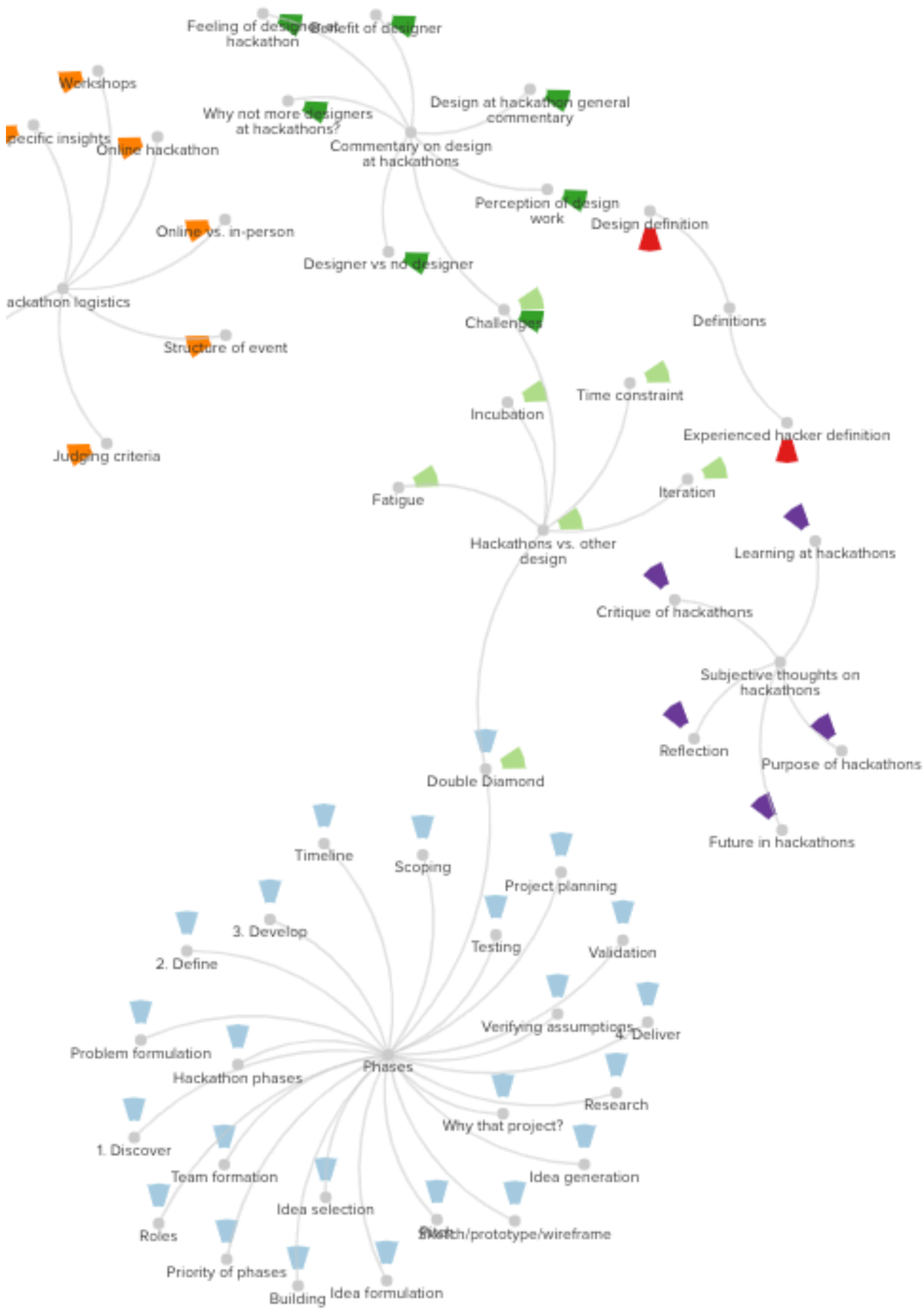
Interestingly, there were no prepared questions that directly asked about collaboration at hackathons. These findings emerged inductively from the interview data.

1. How many hackathons have you participated in?
    a. Would you consider that number to be a lot or a little?
2. In your own words, what would you say were your group's goals at the hackathon(s)?
3. Can you please define design?
4. What is your experience in design?
5. Would you consider yourself to be a novice or experienced hacker?
    a. Why?
6. Would you consider yourself to be a novice or experienced designer?
    a. Why?
7. Would you say that your goals and experience resulted in a different hackathon experience than your teammates or other teams?
8. When you compare your design process at the hackathon(s) how does it differ to more typical design projects?
9. What steps did you engage in, or activities did you do, throughout the hackathon? (From start to pitch)
    a. What challenges were at each? How did you overcome them?
10. What things during the hackathon made getting to your solution more difficult?
    a. How did you overcome these difficulties?
11. What things made it easier?
12. Were you able to take any breaks during the hackathon?
    a. Why or why not?
    b. What did you do during the breaks?
    c. Did you participate in any hackathon-run workshops?
    d. How long did the breaks last?
    e. Did you continue to work on, or think about, your project during the break?

Appendix C

Candidate Thematic Map





The interactive Candidate Thematic Map can be viewed here.

Appendix D

Codes by Thematic Cluster

Cluster	Label	Description
Typical hackathon experience	1. Discover	Parts of the hackathon design process that align with the Discover phase of the Double Diamond Design Process
	Idea generation	A description of the idea generation process
	Why that project?	The reason the participant's team(s) chose to build their hackathon project(s)
	Problem formulation	A description of how team(s) refined their problem
	Research	A description of the research conducted at the hackathon(s)
	Team formation	A description of how the hackathon team(s) were formed
	Roles	The group roles in the hackathon team(s)
	2. Define	Parts of the hackathon design process that align with the Define phase of the Double Diamond Design Process
	Idea formulation	A description of how team(s) refined their idea
	Idea selection	A description of how team(s) selected their solution
	Project planning	A description of how team(s) developed a plan for their project
	Scoping	A description of how team(s) defined and narrowed project scope
	Validation	A description of team efforts to validate the problem and solution
	Verifying assumptions	A description of how team(s) identified assumptions and validated them
	3. Develop	Parts of the hackathon design process that align with the Develop phase of the Double Diamond Design Process
	Building	A description of team efforts to build their project
	Sketch/prototype/wireframe	A description of the use of creating sketches, wireframes, and other prototypes
	4. Deliver	Parts of the hackathon design process that align with the Deliver phase of the Double Diamond Design Process
	Pitch	A description of the pitch development and delivery
	Testing	A description of team(s) testing their projects
	Challenges	Identification of the biggest barriers to designing a project at hackathons
	Designathon	Mention of designathon or design-focused hackathons
	Hackathon goal	The goal of the hackathon(s) attended
	Judging criteria	A description of the criteria judges considered
	Online hackathon	Mention of online hackathons
	Online vs. in-person	A comparison between online and in-person hackathons

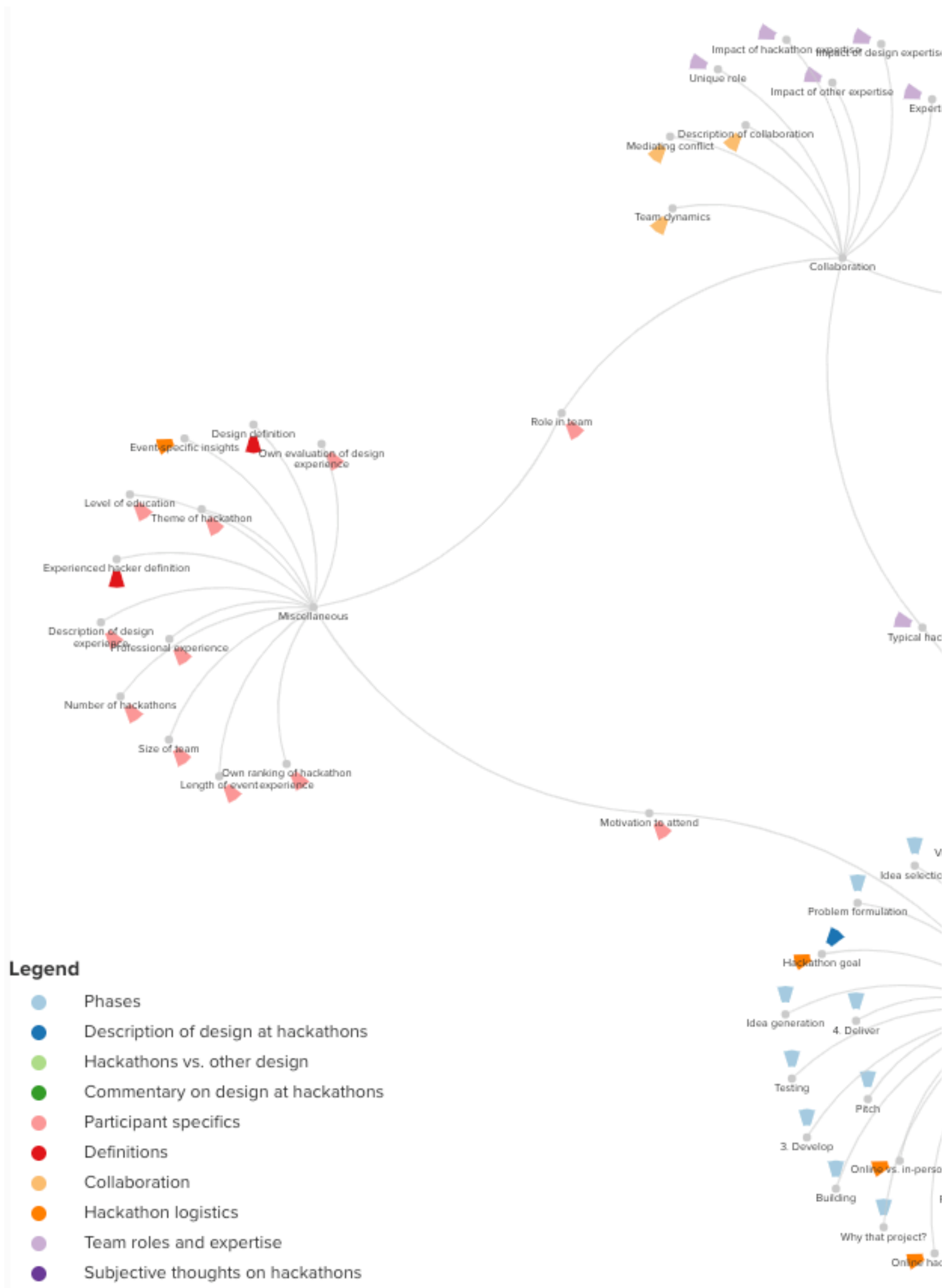
	Structure of event	An overview of the structure of the hackathon(s) attended
	Workshops	A description f the workshops offered at the event and those attended by the participant
Design at hackathons	Agile	A connection between hackathons and agile methodologies
	Consideration of user	How the team considered the user in their design
	Design at hackathon general commentary	The participant's perception of design work at hackathons
	Barriers to design at hackathons	A description of challenges to implementing design practices at hackathons
	Design tools/methods	A descriptions of design tools and/or methods used by the hackathon team and for what purpose
	Designer vs no designer	A comparison of experiences when a designer was present on the team versus when they were not
	Benefit of designer	Observed benefits of having a designer on a hackathon team
	Fatigue	A description of feelings of fatigue and how that affected their progress
	Feeling of designer at hackathon	Accounts of designer participants' feelings at hackathons
	Hackathon phases	Identification of phases of the hackathon design process
	Double Diamond	A connection to the Double Diamond Design Process
	Priority of phases	How participants prioritized the phases of the hackathon design process
	Timeline	A brief breakdown of the hackathon timeline
	Hackathons vs. other design	A comparison between hackathons and other design projects
	Incubation	A description of instances of incubation and breaks at hackathons
	Iteration	A description of instances of iteration at hackathons
	Perception of design work	How participants viewed design work at hackathons
	Responsibilities of designer at hackathons	A description of the designer role
	Speed of designing	A description of how quickly design occurs at hackathons
	Why not more designers at hackathons?	Participant's thoughts on why designers are in the minority of hackathon attendees
Collaboration	Role in team	The role the participant took in the hackathon team
	Description of collaboration	Details about how the team collaborated
	Mediating conflict	How tension was resolved in the team
	Team dynamics	A description of how well the team worked together
	Expertise	What existing knowledge the participant held
	Impact of design expertise	How the participant's design knowledge impacted the hackathon project

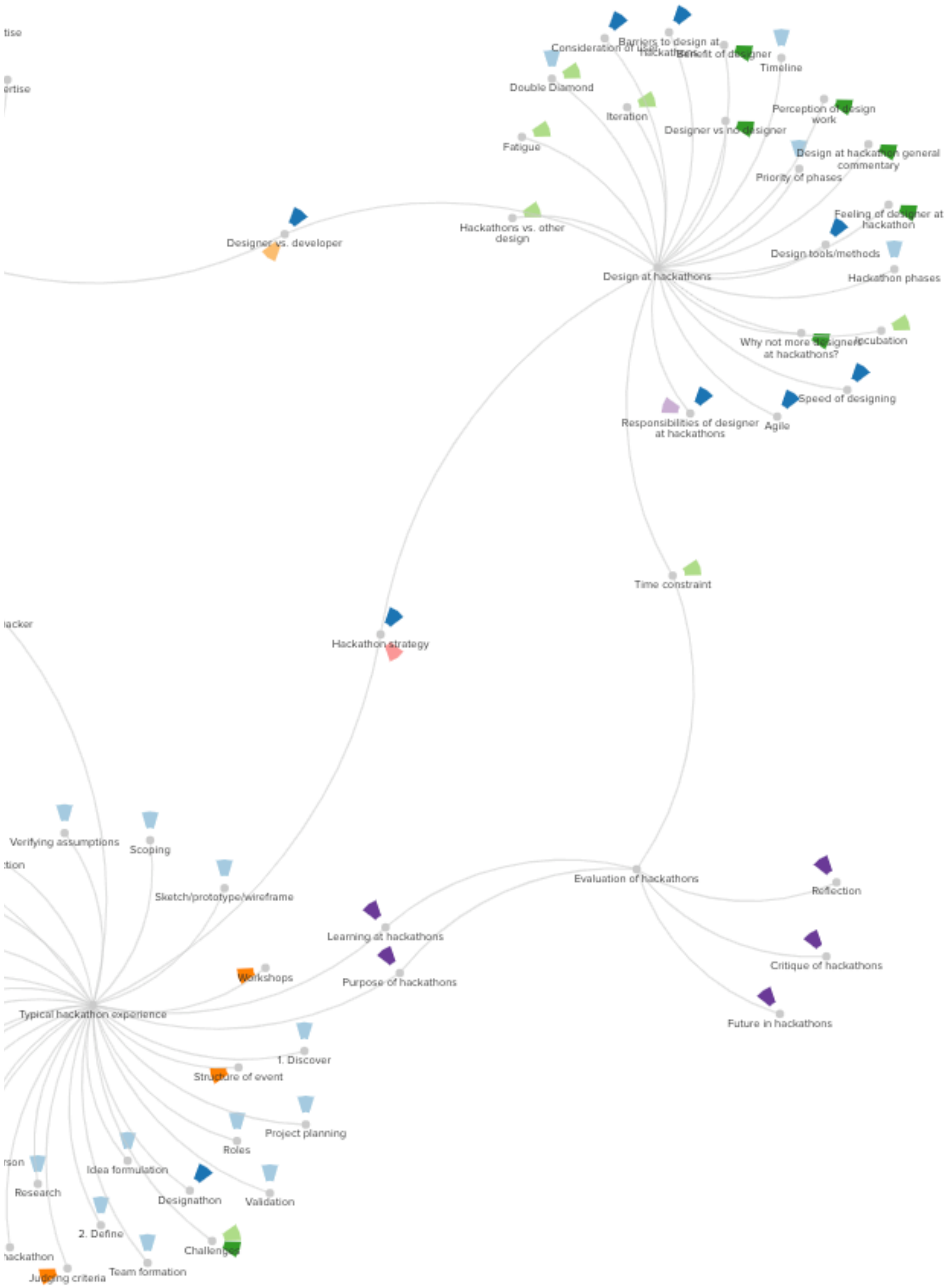
	Impact of hackathon expertise	How the participant's previous hackathon experience impacted the hackathon project
	Impact of other expertise	How the participant's existing knowledge in either development or business impacted the hackathon project
	Unique role	A description of a role outside the typical developer, designer, business roles
Miscellaneous	Length of event	Duration of the hackathon(s) the participant attended
	Level of education	The highest level of education of the participant
	Number of hackathons	How many hackathon(s) the participant attended at the time of their interview
	Professional experience	The length and industry of the professional experiences of the participant
	Size of team	The size of team(s) the participant collaborated with
	Theme of hackathon	The theme/topic of the hackathon(s) the participant attended
	Design definition	The definition of 'design' the participant holds
	Description of design experience	A description of the experience the participant has with design
	Own evaluation of design experience	An evaluation of the extent of the participant's design experience
	Event-specific insights	Comments on specific aspects of a hackathon event
	Experienced hacker definition	How the participant defines an experienced hackathon participant
	Own ranking of hackathon experience	An evaluation of the extent of the participant's hackathon experience
Collaboration, Design at hackathons	Designer vs. developer	A description of tension between developers and designers
Design at hackathons, Evaluation of hackathons	Time constraint	A description of time constraints and their impact at hackathons
Evaluation of hackathons	Future in hackathons	Participant's thoughts on whether they would attend another hackathon
Evaluation of hackathons	Critique of hackathons	Participant's critiques of hackathons
Evaluation of hackathons	Reflection	Participant's reflections on their hackathon experience(s)
Miscellaneous, Typical hackathon experience	Motivation to attend	Why the participant attended the hackathon(s)
Typical hackathon experience, Collaboration	Typical hacker	A description of the typical hackathon participant

Typical hackathon experience, Design at hackathons	Hackathon strategy	The strategy the participant had at the hackathon(s)
Typical hackathon experience, Evaluation of hackathons	Purpose of hackathons	The participant's understanding of the purpose of hackathons in general
Typical hackathon experience, Evaluation of hackathons	Learning at hackathons	A description of what and how the participant learned at the hackathon(s)

Appendix E

Final Thematic Map





The colours from the first iteration of the thematic map (Apendix C: Candidate Thematic Map) were kept in the final map included here to visually display the changes into the new clusters.

The interactive Final Thematic Map can be viewed here.