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Virtual design hackathons: a data collection framework

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Abstract

Design hackathons offer a unique research opportunity to study time-pressured collaborative design. At the same time, research on design hackathons faces unique methodological challenges, prompting the exploration of new research approaches. This paper proposes a new data-collection framework that leverages a virtual format of hackathon events and enables a deeper insight into hackathon dynamics. The framework applicability is presented through a case study of the IDEA challenge hackathon, in which different intrusive and non-intrusive data collection approaches were used.

Keywords: design activities, process analysis, design research, design tools, collaborative design

1. Introduction

In line with the widespread adoption of hackathons across different domains, design hackathons have become an increasingly popular means for fostering design innovation and collaboration. These events offer a platform for designers, engineers, and enthusiasts to come together, share ideas, and rapidly prototype solutions to real-world problems. Namely, hackathon participants typically work tirelessly, often also during the night, to refine their ideas and prototypes, and showcasing their solutions in competitive presentations known as "pitches" (Flus and Hurst, 2021a). For them, the competitive and immersive nature of hackathons, coupled with the opportunity to network with like-minded individuals and industry experts, provides a creative challenge and a chance to demonstrate their skills (Briscoe and Mulligan, 2014; Pe-Than and Herbsleb, 2019). At the same time, design hackathons are also valuable for organizers, typically design companies and universities, as they can facilitate innovation, foster community engagement, and help identifying emerging talents (Falk *et al.*, 2022; Flus and Hurst, 2021b). Moreover, hackathons provide an ideal environment for experiential learning and hands-on problem-solving (Siena *et al.*, 2023).
In addition to the benefits for the participants and organisers, design hackathons also offer a unique opportunity for design researchers to study design activity under extreme time constraints, providing valuable insights into the dynamics of collaborative design processes and the impact of time pressure on creative decision-making (Ege *et al.*, 2023; Falk *et al.*, 2022; Flus and Hurst, 2021b; Sadovykh *et al.*, 2019). Studying design hackathons can thus potentially lead to the development of methodologies adaptable to real-time projects, enhancing design practice by integrating time-efficient ideation techniques.

It could also inform the educational practices, enabling educators to tailor curricula in a way to simulate real-world, time-sensitive design challenges and preparing students for professional scenarios.
Still, despite their growing appeal, design hackathons remain relatively underexplored in academic research. Traditional methodologies like protocol analysis prove impractical due to the scale of such events, as well as the noisy environment, and limited time for exploration (Flus and Hurst, 2021b).
To address these challenges, innovative research approaches are necessary. For example, one approach involves leveraging online (virtual) hackathons, which provide unique opportunities for data collection through digital platforms, including chat transcripts, video/audio calls, and digital artifacts. However, virtual hackathons introduce challenges such as asynchronous collaboration and reduced interactivity, necessitating careful consideration in research methodologies (Falk *et al.*, 2022; Flus and Hurst, 2021b).
Hence, the primary objective of our paper, guided by the research question *'How can a comprehensive data collection framework be designed to effectively capture the dynamics of design teamwork within virtual design hackathons?'*, is to overcome the methodological challenges associated with studying design hackathons, especially in the context of virtually hosted events. By exploring new data-capturing methodologies, we aim to establish a robust framework for investigating design hackathons. We believe that the application of such a framework can provide valuable insights into design activities, enabling researchers and practitioners to gain a deeper understanding of the unique challenges and opportunities presented by hackathon environments.

2. Background

2.1. Design hackathons

Design hackathons, dynamic events where participants collaborate intensively to create innovative solutions within a limited timeframe, have gained significant attention in recent years. They serve as testing grounds for creativity and innovation, thus fostering a unique environment where participants rapidly prototype ideas. The spread of design-specific hackathons, including virtually hosted ones, has prompted a number of research studies aimed at improving the understanding of such events.
Design hackathon-related research has explored various aspects of hackathons, focusing on understanding how participants collaborate, innovate, and create prototypes within tight timeframes. Researchers have investigated topics such as interdisciplinary collaboration, prototyping techniques, problem-solving approaches, and the impact of hackathons on skill development.
The extensive reviews by Flus and Hurst (2021a) and Falk et al. (2022) have emphasized the significance of design hackathons as platforms for exploring new opportunities in design research. Their research delves into the innovative practices that emerge during hackathons, underscoring their potential to push the boundaries of traditional design methods. These studies highlight the dynamic nature of design hackathons, showcasing them as vibrant spaces for experimentation and creative problem-solving.
In the realm of virtually hosted hackathons, there have been efforts not only to provide insights into prototyping behaviours but also to address the challenges of organizing and collecting extensive data during these virtual events (see, e.g., Ege et al., 2023; Giunta et al., 2022; Goudswaard et al., 2022; Kent et al., 2022). The studies mainly revolve around understanding prototyping strategies, exploring the challenges of virtual collaboration, and analysing the complementarity and differences between physical and digital prototypes in these virtual environments.
As design hackathons continue to evolve and diversify, understanding the nuances of these events becomes vital. In this context, the consolidation the of above-mentioned studies lays the foundation for our understanding of design hackathons and helps us in establishing the fundamental consideration for the proposed data collection framework. By building upon the insights gathered from these studies, our research aims to delve deeper into methods and tools for collecting data on the collaborative dynamics, prototyping strategies, and participant behaviour in design hackathons.

2.2. Methods and tools for data collection during hackathons

Previous efforts in hackathon research have employed various methods and tools for data collection in order to gain a comprehensive understanding of participant behaviours, collaboration dynamics, and

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prototyping strategies. For example, in their review of hackathon research, Flus and Hurst (2021a) report on the use of experimental methods, autobiographical methods, observations, surveys interviews and focus group, etc. They emphasise that studying hackathons presents challenges due to their dynamic and noisy nature, making traditional methods like protocol analysis impractical; therefore, researchers in the reviewed publications most often had to utilise labour-intensive methods like interviews and ethnography, limiting the study scope and generalizability across diverse hackathon events. Since these methods require a lot of manual effort from the researchers, only few groups can be studied at a singular event (Falk *et al.*, 2022). On the other hand, the vast amount of data generated at hackathons, including text-based communication and project details, suggests potential for innovative data-driven techniques like text mining and natural language processing (Flus and Hurst, 2021b).

In addition, novel and innovative data-driven approaches were also used to study prototyping, which is often a central focus in hackathons. For example, Nelson et al. (2019) developed ARCHIE, an automated data collection method, enabling precise analysis of physical prototyping efforts. Erichsen et al. (2021) introduced Protobooth, a digital tool capturing physical prototypes, providing detailed data on design evolution. Prototype-related data can be examined using network analysis and visualization techniques, which can offer a comprehensive view of social and collaborative aspects of hackathons. For example, Kent et al. (2022a) employed these methods to map relationships and collaborations among participants, providing insights into the complex web of interactions within hackathon teams.

Furthermore, survey questionnaires have been instrumental in understanding participants' perspectives. For example, surveys conducted after the event, which incorporate demographic inquiries, can reveal variations in participants' experiences based on their diverse backgrounds. Additionally, surveys can occasionally be used as both pre- and post-event measurements, evaluating interventions introduced during the event (Flus and Hurst, 2021b), whereas certain hackathons incorporate continuous feedback platforms throughout the event, alongside pre- and post-event surveys (Falk *et al.*, 2022).

The use of the abovementioned methods and tools is particularly relevant for an event called IDEA challenge, which is a series of design hackathons oriented towards design activity research and data collection. Namely, both Protobooth and surveys were used in the first two editions of IDEA challenge and proved to be convenient methods of collecting uniformly structured data for different individuals and teams who participated in these hackathons (Ege *et al.*, 2023; Goudswaard *et al.*, 2022). Nevertheless, while these methods can offer valuable insights into participant behaviours and collaborative processes, researchers generally agree that collecting data during hackathons still presents a unique set of challenges. The IDEA challenge is briefly introduced in the following section.

2.3. The IDEA challenge

The International Design Engineering Annual (IDEA) challenge is an annual design competition involving labs from the engineering design academic community. In general, IDEA challenge aims to (1) apply the finest minds in the engineering design research (EDR) community to address real-world global design challenges; (2) facilitate a collaborative and competitive working environment used as a design study to be run by the host institution including shared datasets; and (3) foster community across engineering design groups. These areas are of particular importance for the design community during the three-year period without in-person conferences (2020-2022), meaning that many postgraduate researchers have not interacted extensively with others in their research field. As such, the IDEA challenge has proved to be an effective means of building a design research community.

The inaugural IDEA challenge ran in September 2021 and required the development of vaccine distribution solutions for rural, hard to reach communities in Colombia. Fourteen participants from four institutions, spent four days designing and prototyping solutions (over 200 prototypes) before a final pitch to a panel featuring both industry and academic experts (Goudswaard *et al.*, 2022).

The second IDEA challenge ran in April 2022 and required the development of a low-cost hydro-power generator to collect rainwater energy. Eighteen participants from five institutions participated in the hackathon and, again, more than 200 prototypes were created. Necessary prototyping and testing supplies were sent in advance (Ege *et al.*, 2023).

The third IDEA challenge event was held in May 2023 and is described in more detail in the following sections.

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3. Hackathon data collection framework

Following literature review and prior IDEA challenges, we propose a data collection framework for design hackathons (Figure 1). The proposed data collection strategies can be broadly categorised into intrusive and non-intrusive, whereas the intrusive data collection is further classified into stepped and retrospective. Stepped data collection is a recurrent one that aims at gathering data for the analysis of dynamic processes that occur during hackathons. For instance, a recurrent survey can be given to participants every one or two hours to answer who has been working in the last period, what kind of prototypes they developed, etc. In the case of recurrent work sampling, researchers should consider the participants' load and intrusion. Therefore, the frequency and duration of the work sampling should be set to the minimum values needed to answer the study research questions. In case that the research questions might be too sensitive on recurrent survey, another approach could be a retrospective interview and/or survey with a hackathon team (individually or collectively, depending on what is studied). These interviews could be used to gather information about various aspects of hackathons, such as prototype evolution, hackathon process, work distribution, collaboration. Researchers should organise interviews immediately following the hackathons, to prevent inconsistencies in the data due to memory loss. Given the time-intensive activity of hackathons, intrusive data collection might have significant consequences on hackathon execution. In addition, the collected data is subjective and is usually just a perception of the respondents rather than being objective assessment. Therefore, the focus should be on non-intrusive data collection.

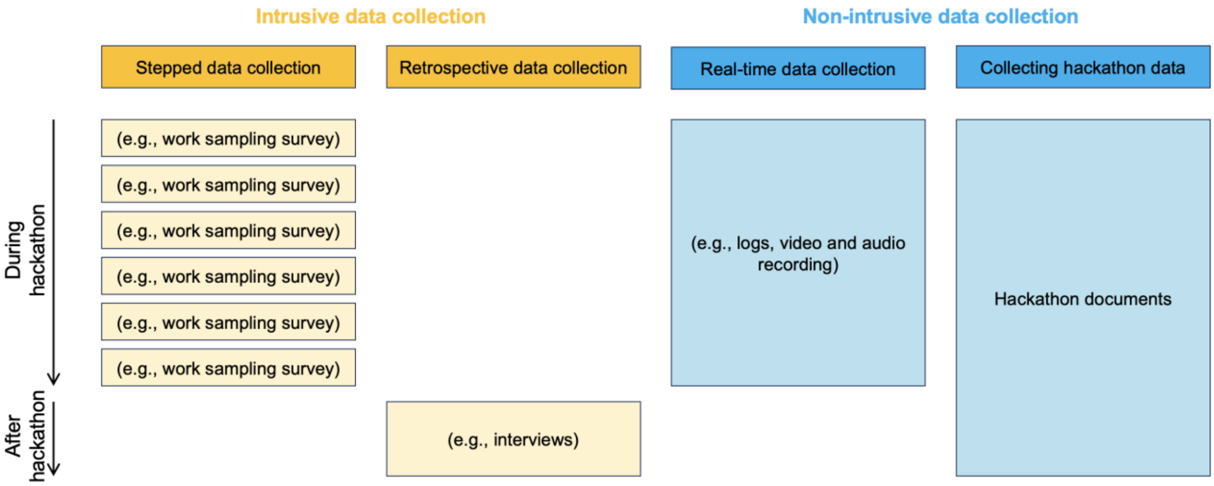

Figure 1. Data collection in design hackathons

Non-intrusive data collection includes real-time data capture which can be in the form of automatic reporting from various tools (e.g., activity logs) during hackathons or recording data that can be used for future analyses (e.g., using protocol analysis). In terms of researcher's load for analysis, activity logs might require significantly less processing time than video and audio recordings, as the data could be labelled while being collected. In contrast, video and audio recordings are usually processed using a protocol analysis approach that results in labelled items. Although there are attempts to automate this process (Becattini and Alberio, 2022; Kan and Gero, 2017), content analysis is usually conducted using manual labour, thus taking a significant amount of time. Another type of non-intrusive data collection is the analysis of hackathon documents, such as analysis of created prototypes, reports, presentations, and evaluation. Similar to the analysis of video and audio recordings, collecting this data requires post-processing which is usually a manual content analysis. Therefore, non-intrusive data collection from activity logs provides a great potential for analysing hackathons.

This can be achieved by collecting as much information as possible from the tools that are being used throughout the hackathon. Therefore, a design hackathon tools classification has been proposed. These tools are divided into prototyping, communication, and data sharing. Prototyping tools serve as a support for creating design artefacts that enhance communication, increase learning, and inform decision-making (Lauff *et al.*, 2018). These tools can be physical (e.g., 3D printing, pen and paper, LEGO,

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whiteboard) or digital (e.g., digital whiteboard, CAD tools). Physical tools are usually more intuitive than digital ones but are less editable and less transferable (important for virtual hackathons). In addition, digital tools provide better support for automatic data collection through activity logs. For example, while utilising digital whiteboard, automatic reporting might collect data such as who created a prototype (e.g., digital sketch) at what time and who else was present while creating a prototype. In addition, the tool might also collect logs at what time other team members saw this prototype (in case of asynchronous work) or estimate the amount of time spent on creating, discussing, editing a specific prototype. This data could be used to track prototype evolution and interaction between team members through prototypes.

Another set of tools are related to communication, which can be broadly divided into communication with team members and communication with organisers. Communication with team members during hackathons is usually intensive. Therefore, it is suggested that organisers opt for real-time communication (e.g., video conferencing tool, instant messaging). In addition to providing a general team communication channel, tools should also enable sub-team communication as well as quick exchange of communication channels. This enables hackathon teams to split into smaller sub-teams and quickly switch from one sub-team to another. Collecting data from communication tools could be related to a content or communication structure analysis. Content analysis could be achieved through automatic transcription and further analysis of hedge words using natural language processing (Mohammad and Turney, 2013). Communication structure analysis could be achieved by automatic segmentation of communication into a speaker and listener (e.g., participants that took part in conversation). This segmentation enables identification of participants that spoke the most, that were present in most of conversation, etc. In addition, dynamic processes could be analysed, such as communication patterns (e.g., talking, and silent periods as the hackathon proceeds, interchanges of participants, etc.).

Another set of tools are related to data sharing, depicting data and documents that are not shared through prototyping tools. Although many communication tools (e.g., Microsoft Teams, Gather) enable data sharing, it is suggested that participants have dedicated folder that they can use for storing and sharing documents. This dedicated folder provides all the shared documents at one place, which is vital for time-intensive activities such as hackathons. Collecting data from sharing tools could be accomplished by capturing timestamp and participant name logs. The logs could be saved every time a participant opens or modifies a specific document.

This framework provides a generic overview of the data that could be collected from hackathons in order to better understand them. The next section presents a case study that utilised the proposed data collection framework.

4. IDEA challenge 2023 - Case study

The IDEA challenge 2023 was used as a case study was to demonstrate the applicability of the predefined data capturing methods and to showcase how they can provide a detailed, multi-level overview of teams' design processes during a virtual hackathon. IDEA challenge 2023 was the third edition of the virtually organised hackathons and was run in a revised format compared to the previous two.

4.1. Challenge format and task

The hackathon's duration was reduced from four days to a compressed 30-hour timeframe, from 10:00 CET on the first day to 16:00 CET on the second day. A total of 15 participants from five European countries took part in the challenge. The participants already applied in teams of three, so there was one team per each country. Whilst both Master and PhD students were allowed to participate, the majority of participants were PhD students, with background in engineering design.

The design task given to participating teams was to develop a CubeSat for monitoring of freshwater supplies, specifically focusing on the African region. The design brief provided details on CubeSat's primary mission, including data collection on water quantity and environmental monitoring for early contamination warnings in freshwater lakes. The brief also outlined a set of ten requirements, covering aspects such as form factor (1U), maximum mass, necessary onboard systems, minimal solar panel size, and general durability in space conditions. Participating teams were given a set of resources to facilitate

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the design process, including documentation on CubeSat standard specifications (CubeSat, 2023), drawings of the 1U form factor, CAD models, recommended off-the-shelf component suppliers, and a NASA guide on CubeSat design and development (NASA, 2023).

The hackathon was organised into five stages, as depicted in Figure 2. Teams received relevant information a day before the event, including instructions for accessing the virtual venue, schedule, and permissible methods and tools guidelines. The opening ceremony, lasting approximately 40 minutes on the first day, provided an overview of the IDEA challenge, the design task, available resources, and expected deliverables. Following this, teams were directed to their private areas in the virtual venue to commence work. Throughout the hackathon, at least one organiser remained available in the common area to provide technical support and task clarification.

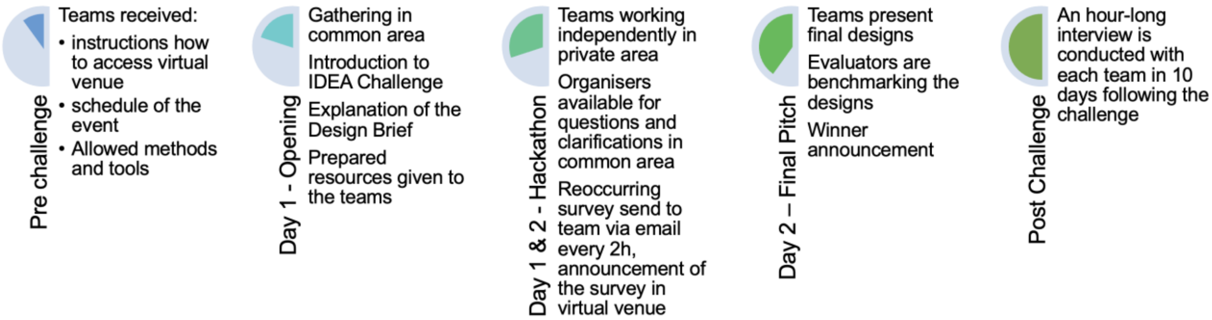

Figure 2. Timeline of the IDEA challenge

4.2. Data-collection setup

Before the event, a set of design hackathon tools was set up according to the proposed framework. These tools were used during the hackathon to conduct the design task and gather data about the design process and teams' dynamics. As a communication tool during the hackathon, we used the Gather platform (www.gather.town). It is a virtual coworking space that combines spatial design and video conferencing, where participants, represented by avatars, can navigate through these spaces, engage in video chats, and interact in real time, providing a dynamic and immersive virtual experience. The virtual venue was organised in five private areas (one for each team) with restricted access only for team members and a common area for all participants. As prototyping tools, participants were allowed to use hand-made sketches, digital sketches, CAD modelling tools, and simple physical tools for prototyping (e.g., papers, cardboard, etc.). However, they were instructed to put pictures of each prototype onto the Miro board, an online collaborative whiteboard platform designed for visual collaboration among teams and individuals. Finally, each team had a dedicated sharing tool in the form of a shared repository (Google Drive) through which digital files were shared and final deliverables submitted. Links for the Miro board and Google Drives were embedded in the private area of each team. To enable the gathering of stepped data during the hackathon, the time frame of the hackathon was divided into 2h blocks (15 blocks in total). Teams were also instructed to start working in a new block on the Miro board every two hours. On the second day, teams submitted their final designs, and each team presented their work to other teams, a jury, and invited guests. Subsequently, the jury reviewed and benchmarked the designs before announcing the winning team.

The challenge set-up was aligned with the proposed framework for data collection, encompassing both intrusive and non-intrusive methods, enabling us to collect various qualitative and quantitative data (Figure 3). Intrusive data collection, occurring during the third and fifth phases of the hackathon, involved a recurring survey sent to teams every two hours, a post-challenge group interview conducted via MS Teams and the feedback survey. The recurring survey, a form of stepped data collection, aimed to capture information about the teams' work for the past two hours. The survey was conducted using the online form with four questions about how many prototypes they made, how many team members were working, in which formation, and what ideation tools and methods they used. The challenge of this mode of data collection was how to avoid the intrusive nature of the data collection. For this reason, the survey was limited to only four questions and was filled by a single team member to minimise the

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work disruption. Nevertheless, the recurring survey provided data about the team dynamics during the hackathon. On the other hand, retrospective data was collected through two modes of data collection. Firstly, each participant was asked to fill out the feedback survey, which was also in the form of an online survey with four questions to capture the satisfaction of the participant with the hackathon, their thought on the good and the bad during the hackathon as well as collect suggestions for future hackathons. The second retrospective data collection occurred during the interview process. Each team was interviewed as a group in the days following the hackathon. The semi-structured interview lasted approximately one hour and was moderated by one of the researchers who followed the set of prepared questions but also asked questions when necessary. Another researcher observed the interview and took notes. Furthermore, the interview was conducted using MS Teams videoconferencing, which enabled us to record the audio of the interview and create an automatic transcript.

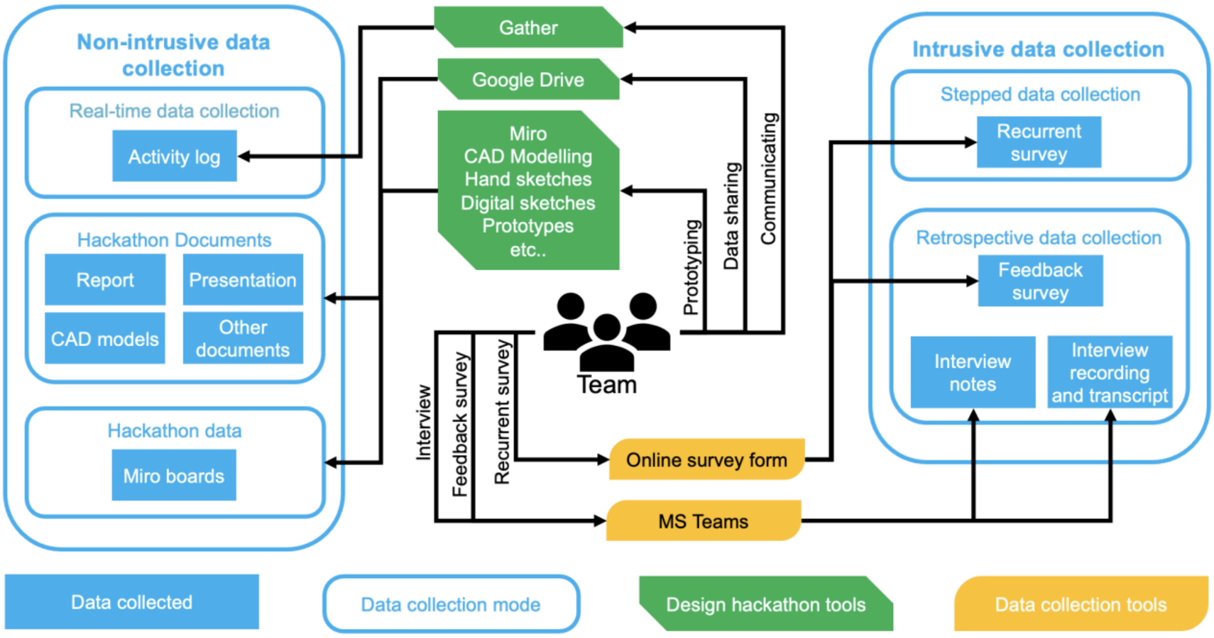

Figure 3. Data collection during the IDEA challenge 2023 according to the proposed framework

Non-intrusive data collection took place in three ways. Real-time data capture occurred through the Gather platform, enabling the collection of speaking times and listener identification. This provided a data log about who was speaking, when, for how long and with whom, a rich quantitative data set that depicts the dynamic of conducted teamwork. The Miro board used by all the teams was the second non-intrusive data collection mode. The Miro board was divided into 2h blocks and contained pictures of the prototype and other data depicting the design's evolution. Finally, during the hackathon, teams generated various documents, including reports, CAD models, evaluation sheets, etc. These documents were saved to dedicated repositories and collected at the challenge's end, providing the final data source.

4.3. Collected data example

Due to the format and the space available in this paper, we will only present a fraction of data that can be captured and compared for different scales of the design process, e.g., the macro, meso and micro scale of analysis (Cash *et al.*, 2015).

At the top level (macro scale) there is the high-level, retrospective data collected during the post-challenge group interviews. The recordings and notes taken during these semi-structured interviews provide a qualitative overview of the team's approach to solving the challenge and their design process - how they divided the work, which methods and tools they used, their overall satisfaction, what they would have done differently, etc.

At the middle level (meso scale) there are the recurring surveys, which provide a more detailed description of the team's processes, given that new data points have been generated every two hours. As such, this data can be used to describe the dynamics of the team's design process, particularly from the

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perspective of its team members, that is, how they have perceived the past two hours of the challenge at the time of filling in the survey. These insights can then be additionally enriched using the content shared by the participants via Miro boards during each of the time blocks.

At the bottom level (micro scale) there is the real-time data collection in the form of the activity logs captured non-intrusively by the communication tools used throughout the challenge. This is also the most extensive dataset, containing hundreds of data points for each of the time blocks. The most interesting is the data log about the verbal interactions between the participants in Gather.

The three levels collected data can be depicted using an example of team Forrest, which is the team that won the IDEA 2023 challenge. The comparison presented in Figure 4 focuses only on the interaction patterns reported during the interviews, recurring surveys, and activity logs. More precisely, it compares the nature and mode (individual, sub-team, team) of collaborative work and verbal interaction between team members based on data collected at these three levels. The top level contains a set of team interview annotations related to the various hackathon phases (ordered in a timeline). The middle level contains the mode of work (entire team, sub-team or individually) reported in the surveys every two hours. Finally, the bottom layer visualises the intensity of recorded verbal interaction between team members. If this analysis were conducted for all participating teams, its objective would be to examine the dynamics of teamwork and communication within a design hackathon. It would enable an objective comparison of the varied approaches taken by different teams in navigating hackathon challenges and identify what separates the best from the rest. Furthermore, given the constraints on space, specific details on how the analyses were conducted are not included, focusing instead on showcasing the potential of the framework for future research applications.

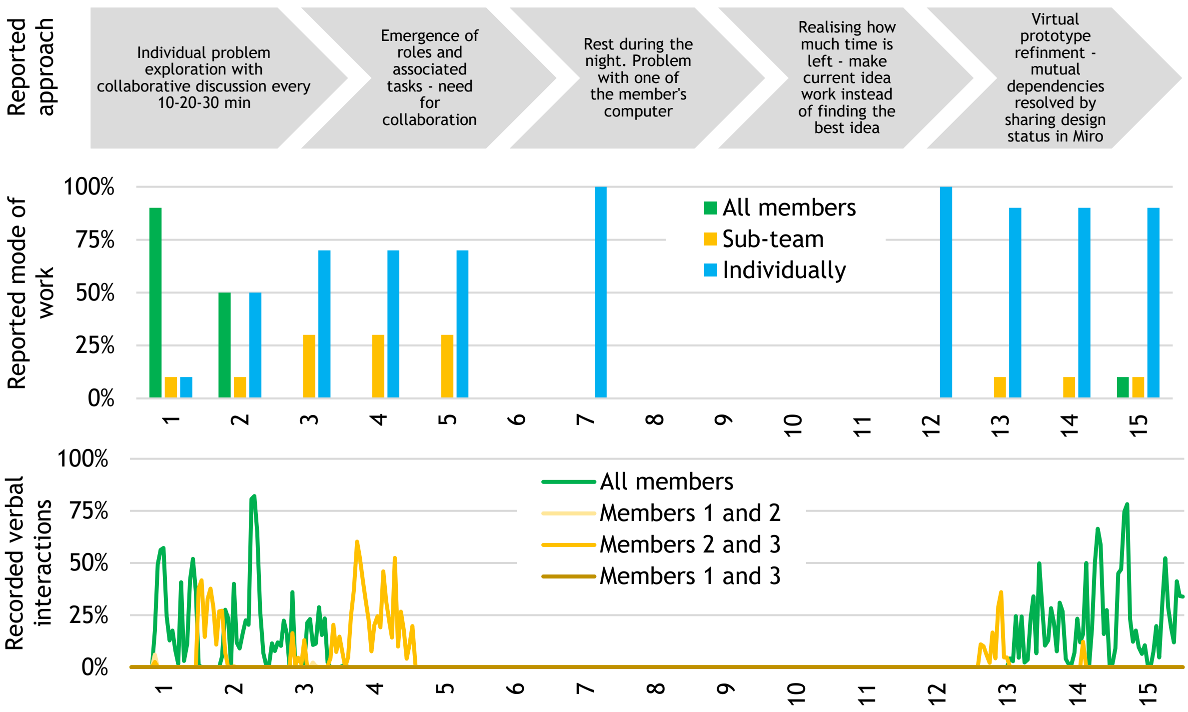

Figure 4. Comparison of reported approach (interview), mode of work (survey) and recorded verbal interactions (Gather) throughout the 15 time blocks of the IDEA challenge hackathon

5. Discussion and outlook

The proposed framework introduced a new virtual environment for collaboration, and when comparing Gather with conventional video conferencing platforms like MS Teams, several noteworthy advantages emerge. A vital feature of Gather's spatial design is the ability to visually discern which teams and their members were online and working. This enhanced teams' awareness about which team was also active. When asked about this during the interview, the teams confirmed that it was motivating. The ability to

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visualise team presence and activities in a spatial context represents a significant advancement in creating a virtual environment that mirrors the interactions found in physical spaces. This could influence team dynamics and overall collaboration during events like hackathons. Furthermore, the spatial design of the virtual environment offered researchers the valuable ability to monitor team activities in real-time. While in this challenge, we only used this feature from an organisational point of view to ensure the hackathon ran as planned, this feature could also be used in future hackathons to take notes about team progress, identify potential challenges and observe emerging patterns in real-time.

Furthermore, the presented fraction of collected data from the case study demonstrates the potential of the proposed framework for virtual design hackathons. The multi-scale analysis can help to shed more light on the patterns in the data. The used approach proposes a top-down analysis, with the initial pattern being identified from the highest scale available, i.e., interviews that capture data on macro-scale. The perception of the team that they were reciprocated from individual to teamwork is in line with the prior findings on the hackathon analysis (Huić *et al.*, 2023). This pattern was then exploited further on the lower-granularity level (i.e., meso-scale) using data from the recurrent survey. Analysing reports on a two-hour interval showed that team members worked more together at the beginning of the hackathon, while worked more individually towards the end of the hackathon. The reason behind this pattern might be the difference in the nature of work at the beginning and at the end of the hackathon. At the beginning, participants mainly work on problem analysis and synthesising solutions, which might require all team members to agree on how they would proceed. As they go towards the end, different roles emerge, and the work is divided accordingly. Furthermore, analysis of the recurrent survey also identified that team members did not communicate throughout the night hours, suggesting that individual work might depend not only on the phase of the hackathon but also on the availability of the team members.

While the recurrent surveys provided lower-granularity level data, these results are still not on the micro-scale level (Cash *et al.*, 2015). In addition, the recurrent survey is intrusive and subjective. Therefore, activity logs were used to get more objective, non-intrusive and real-time quantification of individual and teamwork interchange, highlighting the complementary perspectives of different data collection methods where the traditionally overlooked objective data from activity logs validates insights derived from subjective sources. This analysis of interaction could help answer on research questions related to micro-processes in teams, such as what connection of these processes to performance. The similar pattern has been found for the traditional design activities (Cash *et al.*, 2020). However, it remains unclear to what extent these patterns relate to time-intensive activities such as hackathons. While the same pattern is being analysed throughout the granularity levels, it enabled answers to different research questions. The results here showed the top-down connection of the data. Researchers might utilise any other connection between different layers. For instance, a quantitative analysis of big data at the micro-scale level might identify patterns that researchers might explore on the higher granularity levels, i.e., bottom-up approach. Despite the approach, combining various granularity levels might shed more light on the analysis of hackathons, showing thus usefulness of the proposed framework. While the full extent of the case study's application in demonstrating the framework's utility is constrained by the format and space available, preliminary insights suggest its potential for a comprehensive analysis of team dynamics and design processes in virtual hackathons. This underscores the need for further application and validation of the framework in future studies to fully explore its capabilities and limitations. Finally, while the presented framework is tailored to design hackathons, its applicability to other non-design-oriented hackathons or collaborative events remains an area for further exploration.

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References

Becattini, N. and Alberio, L. (2022), “Semi-automatic Analysis of Spoken Interaction Dynamics in Collaborative Design Sessions”, in Rizzi, C., Campana, F., Bici, M., Gherardini, F., Ingrassia, T. and Cicconi, P. (Eds.), Design

Tools and Methods in Industrial Engineering II, Springer, pp. 183–195, https://dx.doi.org/10.1007/978-3-030-91234-5_19.
Briscoe, G. and Mulligan, C. (2014), "Digital Innovation: The Hackathon Phenomenon", Creativeworks London.
Cash, P., Dekoninck, E. and Ahmed-Kristensen, S. (2020), "Work with the beat: How dynamic patterns in team processes affect shared understanding", Design Studies, Vol. 69, p. 100943, https://dx.doi.org/10.1016/j.destud.2020.04.003.
Cash, P., Hicks, B. and Culley, S. (2015), "Activity Theory as a means for multi-scale analysis of the engineering design process: A protocol study of design in practice", Design Studies, Vol. 38, pp. 1–32, https://dx.doi.org/10.1016/j.destud.2015.02.001.
CubeSat. (2023), "Developer Resources", Https://Www.Cubesat.Org/Cubesatinfo.
Ege, D.N., Goudswaard, M., Nesheim, O., Eikevåg, S.W., Bjelland, Ø., Christensen, K.A., Ballantyne, R., et al. (2023), "VIRTUALLY HOSTED HACKATHONS FOR DESIGN RESEARCH: LESSONS LEARNED FROM THE INTERNATIONAL DESIGN ENGINEERING ANNUAL (IDEA) CHALLENGE 2022", Proceedings of the Design Society, Vol. 3, pp. 3811–3820, https://dx.doi.org/10.1017/pds.2023.382.
Erichsen, J.F., Sjöman, H., Steinert, M. and Welo, T. (2021), "Protobooth: gathering and analyzing data on prototyping in early-stage engineering design projects by digitally capturing physical prototypes", Artificial Intelligence for Engineering Design, Analysis and Manufacturing, Vol. 35 No. 1, pp. 65–80, https://dx.doi.org/10.1017/S0890060420000414.
Falk, J., Nolte, A., Huppenkothen, D., Weinzierl, M., Gama, K., Spikol, D., Tollerud, E., et al. (2022), The Future of Hackathon Research and Practice, https://dx.doi.org/10.48550/arXiv.2211.08963.
Flus, M. and Hurst, A. (2021a), "EXPERIENCES OF DESIGN AT HACKATHONS: INITIAL FINDINGS FROM AN INTERVIEW STUDY", Proceedings of the Design Society, Vol. 1, pp. 1461–1470, https://dx.doi.org/10.1017/pds.2021.407.
Flus, M. and Hurst, A. (2021b), "Design at hackathons: new opportunities for design research", Design Science, Vol. 7, p. e4, https://dx.doi.org/10.1017/dsj.2021.1.
Giunta, L., Gopsill, J., Kent, L., Goudswaard, M., Snider, C. and Hicks, B. (2022), "Pro2Booth: Towards an Improved Tool for Capturing Prototypes and the Prototyping Process", Proceedings of the Design Society, Vol. 2, pp. 415–424, https://dx.doi.org/10.1017/pds.2022.43.
Goudswaard, M., Kent, L., Giunta, L., Gopsill, J., Snider, C., Valjak, F., Christensen, K.A., et al. (2022), "Virtually Hosted Hackathons for Design Research: Lessons Learned from the International Design Engineering Annual (IDEA) Challenge 2021", Proceedings of the Design Society, Vol. 2, pp. 21–30, https://dx.doi.org/10.1017/pds.2022.3.
Huić, I., Horvat, N. and Škec, S. (2023), "Design sprint: Use of design methods and technologies", International Conference on Engineering Design, Cambridge University Press.
Kan, J.W.T. and Gero, J.S. (2017), "Characterizing innovative processes in design spaces through measuring the information entropy of empirical data from protocol studies", Artificial Intelligence for Engineering Design, Analysis and Manufacturing, pp. 1–12, https://dx.doi.org/10.1017/S0890060416000548.
Kent, L., Gopsill, J., Giunta, L., Goudswaard, M., Snider, C. and Hicks, B. (2022), "Prototyping through the Lens of Network Analysis and Visualisation", Proceedings of the Design Society, Vol. 2, pp. 743–752, https://dx.doi.org/10.1017/pds.2022.76.
Lauff, C.A., Kotys-Schwartz, D. and Rentschler, M.E. (2018), "What is a prototype? what are the roles of prototypes in companies?", Journal of Mechanical Design, Transactions of the ASME, American Society of Mechanical Engineers (ASME), Vol. 140 No. 6, https://dx.doi.org/10.1115/1.4039340.
Mohammad, S.M. and Turney, P.D. (2013), "Crowdsourcing a Word-Emotion Association Lexicon", Computational Intelligence, Vol. 29 No. 3, pp. 436–465, https://dx.doi.org/10.48550/arxiv.1308.6297.
NASA. (2023), "CubeSat Launch Initiative Resources", Https://Www.Nasa.Gov/Kennedy/Launch-Services-Program/Cubesat-Launch-Initiative/Cubesat-Launch-Initiative-Resources/.
Nelson, J., Berlin, A. and Menold, J. (2019), "ARCHIE: An Automated Data Collection Method for Physical Prototyping Efforts in Authentic Design Situations", Volume 7: 31st International Conference on Design Theory and Methodology, American Society of Mechanical Engineers, https://dx.doi.org/10.1115/DETC2019-97444.
Pe-Than, E.P.P. and Herbsleb, J.D. (2019), "Understanding Hackathons for Science: Collaboration, Affordances, and Outcomes", pp. 27–37, https://dx.doi.org/10.1007/978-3-030-15742-5_3.
Sadovykh, A., Truscan, D., Pierini, P., Widforss, G., Ashraf, A., Bruneliere, H., Smrz, P., et al. (2019), "On the Use of Hackathons to Enhance Collaboration in Large Collaborative Projects : - A Preliminary Case Study of the MegaM@Rt2 EU Project -", 2019 Design, Automation & Test in Europe Conference & Exhibition (DATE), IEEE, pp. 498–503, https://dx.doi.org/10.23919/DATE.2019.8715247.
Siena, F.L., Naik, K. and Watts, P. (2023), "UTILISING HACKATHONS TO ENHANCE THE DESIGN PROCESS FOR ELECTRONICS & PROGRAMMING LEARNING WITHIN PRODUCT DESIGN EDUCATION", Proceedings of the International Conference on Engineering and Product Design Education, EPDE 2023, The Design Society, https://dx.doi.org/10.35199/EPDE.2023.50.