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Virtually Hosted Hackathons for Design Research: Lessons Learned from the International Design Engineering Annual (IDEA) Challenge 2021

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Abstract

This paper provides an overview and appraisal of the International Design Engineering Annual (IDEA) challenge - a virtually hosted design hackathon run with the aim of generating a design research dataset that can provide insights into design activities at virtually hosted hackathons. The resulting dataset consists of 200+ prototypes with over 1300 connections providing insights into the products, processes and people involved in the design process. The paper also provides recommendations for future deployments of virtual hackathons for design research.

Keywords: hackathons, design challenge, prototyping, design methods, design practice

1. Introduction

The International Design Engineering Annual (IDEA) challenge - a virtually-hosted design hackathon - was run for the first time in 2021 and featured co-located design teams distributed across four universities. It was devised to investigate [1] the potential to use such scenarios for the capture of datasets representing prototyping and design activity; and [2] to understand the design activity occurring within virtually hosted hackathons.

In reporting the organisation, set-up and running of a hackathon as a design research study, the aim of this paper is to explore how hackathons hosted virtually can be used to capture useful and rich design research datasets and, by appraising the implemented hackathon, to provide valuable insights for the running of future hackathons.

While some details of the design research study are included, the findings of this will be presented as a separate paper. This paper provides reflections from organisers and participants, as well as an evaluation of the dataset generated in order to appraise the utility of virtually hosted hackathons for design research.

The paper is structured as follows. First, the literature review considers hackathons in the context of design research and identifies the research gap the paper is addressing. The method section then details the operation of the hackathon as well as the set-up and implementation of the design study run with it. The results section presents an overview of the generated dataset. The discussion section considers the quality of this dataset and feedback from the organisers and participants in order to present recommendations for instantiations of future studies.

2. Literature review

To contextualise this paper, paper and identify tools and techniques that could permit a hackathon to be run as a design study, this section will provide a brief overview of design research methods, hackathons in design research, and capturing design rationale in the product development process.

2.1. Hackathons and their applications in design research

The term hackathon was first coined in 1999 and is a portmanteau of the words *hack* and *marathon* (Briscoe and Mulligan, 2014). Typical structures of hackathons involve opening presentations, followed by targeted and accelerated design episodes in which multiple teams design solutions towards similar or identical briefs, typically over periods between a day and a week. They often feature closing pitches, and if a contest element is included, a winner is selected who may or may not receive a substantial prize (Briscoe and Mulligan, 2014). The principal motivations for participating in hackathons are learning, networking and social change (Briscoe and Mulligan, 2014). Hackathons are considered as means to overcome organisational challenges and expedite innovation (Frey and Luks, 2016). As a result, a range of both tangible and intangible outputs are expected from hackathons including new prototypes (Medina Angarita and Nolte, 2020). Participants can be motivated to participate in hackathons for a range of reasons including building skills not related to their day to day work and to demonstrate their capabilities to help with career progression (Nolte *et al.*, 2018).

Affordances of hackathons include that they enable; a focussed interruption-free workspace; co-located knowledge exchange facilitating rapid feedback on technical issues; cultivation of team identity; and, learning opportunities (Pe-Than and Herbsleb, 2019). The greatest potential value of hackathons is in providing the opportunity for people to meet and collaborate to create new links (Briscoe and Mulligan, 2014). In the context of the study of design in hackathons a number of characteristics are noted. First is that designers have less time to think as time-expensive fabrication is also required; second, typically more parallelisation of activities is observed; and, third that agile design methods are applied, generally featuring iteration (Flus and Hurst, 2021a).

Because of this, hackathons offer unique opportunities for studying design activity at the early stages of design, under time pressure, reduced incubation times, and across different levels of design expertise (Flus and Hurst, 2021b). It is however also recognised by Flus and Hurst (2021b) that challenges exist for studying design cognition at these events.

Against challenges associated with increasing remote working, hackathons provide an opportunity for study and data capture. In particular when run virtually, a hackathon format provides both the design scenario and a formalised digital media for collaboration and communication, which in turn provides realism in design scenario and a data capture opportunity. To this end, this work investigates the opportunity provided by virtual hackathons to provide measurements of design activity.

2.2. Measuring design activity

Given the design research opportunities afforded by hackathons, how can design activity within them be measured? Design studies can be broken down into those carried out in a laboratory setting, and those carried out in industry (Blessing and Chakrabarti, 2009). Whilst a hackathon isn't formally carried out in a laboratory it shares many characteristics of this type of study in that:

- **The process of observing**: can feature a pre-determined time, location and duration; can be repeated with different participants; and, features minimal interrupts.
- **The observed process:** is self-contained meaning all data is available and spans the entire design process; is of low complexity (e.g. 10s of parts); permits analysis of the individual; is a fixed assignment (unless change is introduced by the researcher); permits correlations and causalities to be determined; and, creates results that may not entirely relate to reality.

Whilst some characteristics are shared with laboratory-based design experiments hackathons cannot be described as easy to control; whilst constrained in time and space, hackathon design outputs and strategies employed by participants will invariably be very diverse.

Protocol studies are standard methods for studying design cognition where designers' subjective verbal reports of a design activity are analysed to understand their cognitive processes (Ericsson and Simon,

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1982). These methods are however unsuitable for long design processes and large amounts of data (Goldshmidt and Weil, 1998) such as would be observed in hackathon. Moreover hackathons feature large numbers of participants in loud and difficult to control settings, compounding the unsuitability of these methods (Flus and Hurst, 2021b).
Alternate means of studying designer activity include log book studies (McAlpine *et al.*, 2006, 2017). These involve the reviewing of engineers' logbooks to deduce design activity undertaken. These are also unsuitable for hackathons as, due to their rapidly evolving nature, documentation of the design process is likely to be lacking.
As such, while proven to be capable in controlled scenarios, these typical design activity capture methods imply less promise in hackathon formats. This is particularly true when considering a remote working format, where control of working environments, study procedures, and formal data capture equipment (i.e. cameras, microphones, observer prompting) may be less viable, further reducing design scenario control.

2.3. Capturing prototypes

Design activity can also be understood by capturing and measuring artefacts generated in the design process such as prototypes, which are considered to be important objects in the product development process, spanning both physical and digital domains (Wall *et al.*, 1992). The capture of prototypes consists of a representation of the artefact (such as a picture) as well as design rationale which consists of 'not only the reasons behind decision but also the justification for it, the alternatives considered, the trade-offs evaluated and the argumentation that led to the decision' (Lee, 1997).
Two principle means of capturing prototypes during product development were identified in literature. The first of these is Archie, a platform that captures prototypes at pre-determined phases of the design process (Nelson *et al.*, 2019; Nelson and Menold, 2020). At these phases five images of a prototype are taken along with a survey of design rationale information regarding a prototype's requirements, goals, learnings, fabrication tools, fabrication time and value to the design process. Average time to log each prototype is 3.7 minutes - a not insignificant disruption to a designer's activity. The second prototype capture tool is Protobooth. This was developed to capture pictures of prototypes causing minimal disruption to the Product Development Process (PDP) (Erichsen *et al.*, 2020). Multiple images of each prototype are captured by the Protobooth rig, which are then managed in the cloud. Post capture it is possible to add a name to each prototype with a free text entry. Capture of each prototype takes approximately 9s (Erichsen *et al.*, 2020).
These two capture methods can be seen to differ with respect to amount of information captured about each prototype and ease/speed of use. Their similarities lie in that they both require a physical rig to capture a prototype (hence teams need to be co-located or have individual rigs), have fixed sizes of prototype they can accommodate and also only permit the capture of physical prototypes which only partially represent design activity which will consist of both digital and physical prototypes. As such, these methods can be deemed to be unable to enable the measurement of design activity at virtual hackathons.

2.4. Research gap

To summarise the research gap this paper is addressing - hackathons are an emerging area in design research that offer a number of research affordances. However existing methods of measuring design activity such as protocol studies and logbook studies are less suitable for hackathons due to the informality and intensity of design working and as such it is necessary to develop new methods to understand design activity at hackathons (Flus and Hurst, 2021b). Whilst some methods exist for capturing prototypes, these only permit the logging of physical prototypes and also require a physical booth and as such are unsuitable for a virtually hosted event. To run a virtually hosted hackathon as a design study it is therefore necessary to implement new strategies for capturing designer activity. The remainder of this paper details and appraises the implementation of a virtually hosted hackathon as a design study and a new prototype capture tool used to measure design activity within it.

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3. Methodology

3.1. The hackathon / IDEA challenge

The IDEA challenge was organised to explore opportunities and running of virtually hosted hackathons and alternative data capture methods that are appropriate for the remote format. The challenge comprised a single design brief given to four teams distributed across Europe. Each team comprised three or four members who worked in a co-located cell (total 14 persons), with ideas and outputs then shared continent-wide. Data was captured throughout the challenge using Pro2booth, an online prototyping capture system.

Design Brief: The design challenge set was to develop a low-cost vaccine storage unit that can facilitate vaccine distribution in rural, hard-to-reach areas of Colombia. Colombia was chosen as a location as it offers a range of challenges due to a varied climate (from rainforest to desert to glaciers) and necessity for a range of transport types to reach remote communities including light aircraft and boats. The challenge presented can be classed as focus centric and socially oriented (Briscoe and Mulligan, 2014). Teams were required to generate a physical prototype that could be physically tested and validated. This would be combined with digital prototypes such as CAD models, renders or simulations to constitute the final design submission.

Hackathon process: The hackathon ran for 4 days with the problem presented Monday morning, and final pitches occurring Thursday afternoon. The esteemed judges of the pitches and design outputs featured an industry expert, a senior lecturer and two members of the IDEA organising committee. There were daily kick off meetings in the morning of each day and wrap ups in the afternoon. Organisers were always on hand if teams had any issues or queries.

The assessment criteria for hackathon design outputs consisted of: 1) Quality of prototypes captured during the challenge (30%) - evaluated daily; 2) Performance of physical prototype (40%); 3) Final design (15%); and, 4) Final pitch (15%).

As testing real-world vaccines was deemed inappropriate, an egg was used as a proxy. The performance of the physical prototype was calculated via a series of tests; impact tests in which the egg should not break, and temperature tests in which the egg must be maintained at vaccine appropriate temperatures for as long as possible. Precise testing mechanisms were to be determined by the teams themselves. The hackathon was principally run using MS Teams. This was found to be the best platform as it permitted video conferencing (see final pitches shown in Figure 1), provided persistent channels that each team could use individually as well as a global channel that participants could access if any queries or problems. In addition to this, a bespoke prototyping capture platform was used; this will be detailed in the following section.

Figure 1. The final pitches from the IDEA challenge 2021

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3.2. The design study

The hackathon was used as a design study and its aims were twofold. The first was to understand how and why different prototypes are used in a compressed product development process such as that observed in a hackathon. The second was to evaluate the use of Pro2booth - a bespoke platform used for capturing prototyping activity. Pro2booth consists of hardware and online software components. Due to the remote nature of the hackathon, only the software components were evaluated during the IDEA challenge. A full overview of the Pro2booth platform is provided elsewhere in literature (Giunta *et al.*, 2022). Pro2booth builds on the initial work of Protobooth (Erichsen *et al.*, 2020).

The Pro2booth online platform captures: prototype name; pictures of a prototype; description of a prototype; rationale for a prototypes creation; and, insights from making and evaluating the prototype. It also captures the interrelationships between prototypes in terms of any influence they may have had and also connects creators for each prototype. The input interface for Pro2booth is shown in Figure 2. Participants were instructed to use Pro2booth throughout the hackathon. This was incentivised by scoring the quantity and quality of prototypes captured each day. The motivation for this was to make participants capture prototypes in as near real time as possible.

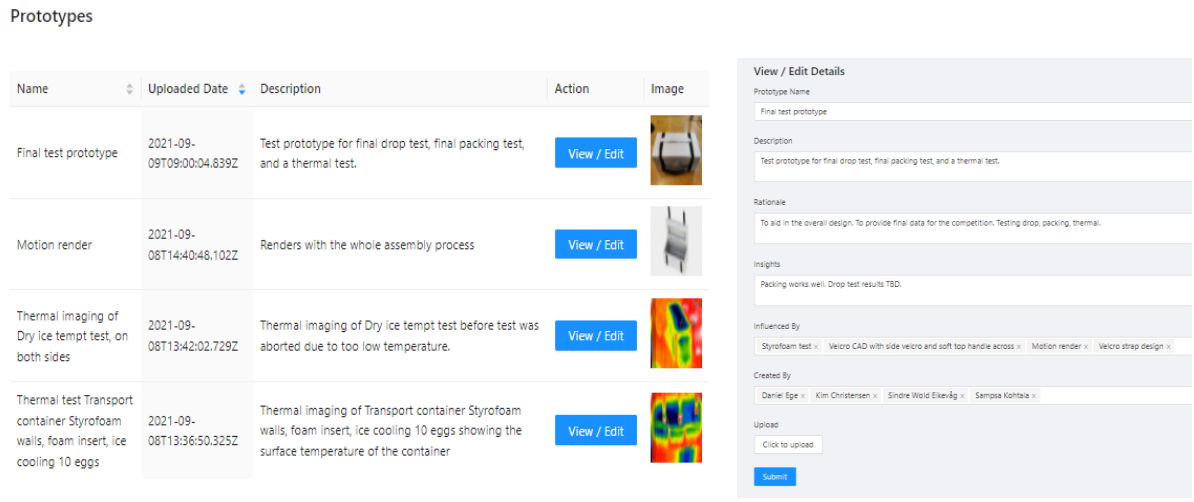

Figure 2. Pro2booth project and prototype interfaces

3.3. Reviewing the design study and the hackathon

To evaluate the hackathon, a survey featuring a range of quantitative and qualitative questions was sent around for completion by all participants three days following the close of the hackathon. These questions are detailed with their responses in Section 5. Following completion and consolidation of these survey results, online workshops were held with participants to discuss how future hackathons associated design studies could be better run in future. In addition to this, participants were surveyed on their reflections on using the Pro2booth platform. Whilst some results are discussed in the following section, a comprehensive review of Pro2booth is the topic of a separate publication.

4. The IDEA dataset

The dataset generated by the IDEA challenge featured a total of 204 prototypes. Additional summary and demographic information on participants can be seen in Table 1. The generated prototypes were varied in fidelity, media, and motivation, as shown in Figure 3 (left). Prototypes were linked to each other by *influenced by* edges and *created by* edges connected to their creators. As such, a number of networks could be constructed as demonstrated in Figure 3 (right) - construction and exploration of these is explored elsewhere in literature (Kent *et al.*, 2022).

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Table 1. Demographic information for IDEA participants. Values In brackets represent numbers of participants

Age (years)	Gender	Position	Field of Study	Design experience
Max: 33 Min: 24 Average: 28	Male - (10) Female - (4)	PhD student - (12) Post-doc - (2)	Mechanical Engineering - (10) Industrial Design engineering - (3) Computer Science - (1)	<2 years - (1) 2-4 years - (5) 4-6 years - (4) 6-8 years - (3) 8-10 years - (1)

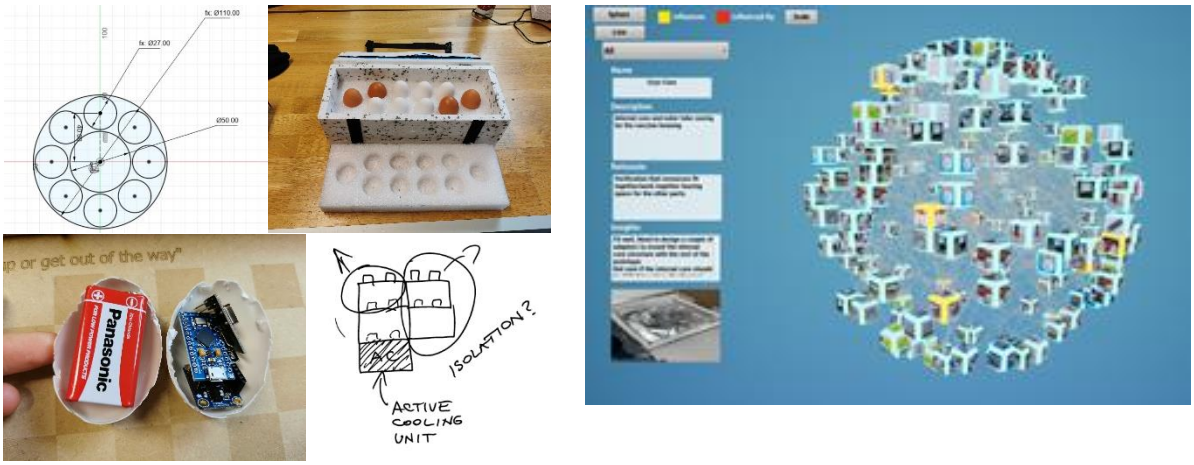

Figure 3. Prototypes captured (left) and network generated from the dataset (right)

5. Evaluating the IDEA challenge and dataset

Evaluation will be carried out on the dataset, its capture method and the IDEA challenge itself.

5.1. Reflections the dataset and its capture method

The dataset can be evaluated according to its richness and the corresponding insights it can provide on the design process employed by designers. Summary statistics for the IDEA dataset are shown in Table 2. The study yielded a dataset of 204 prototypes spanning ideation to final design during the hackathon. This represents a satisfactory quantity of data, with all participants using the tool and providing insights into their design process. In addition to the captures of the prototype, all prototypes entered featured fully completed free text fields with names, description, insights and rationale entered for all prototypes. In contrast with Protobooth where only ~15% of prototypes were given names, ~15% used the free text input and ~8% had both boxes populated thus indicating a low level of completeness.

In addition to the population of data entry fields in the Pro2booth dataset, many interconnections between creator-prototype and prototype-prototype are made throughout the design process (detailed as edges in Table 2) enabling analysis beyond what is typically undertaken in design experiments. This affords explicit connections rather than their being inferred from words of participants. Preliminary analysis has indicated this provides insights into the design processes employed during the hackathon. Further analysis of this is a topic of further work.

In addition to static images, many videos were uploaded to Pro2booth during the study to evidence the evaluation of different prototypes[1]. Whilst these could not be included in the open-source dataset as they identify participants, they do further support the richness of the dataset captured.

[1] Teams greatly enjoyed making and uploading slow motion videos of egg drop experiments, as did the IDEA organisers in reviewing said videos.

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Table 2. IDEA challenge results summary

Category	Teams	Designers	Prototypes	Edges (Created by)	Edges (Influenced By)
Count	4	14	204	373	994

The method of capturing this data can be evaluated according to the level of disruption it causes to the design processes of hackathon participants. This permits elucidation of whether the intention of the capture method being as unintrusive as possible was achieved. To determine this, an exit survey was based on use of the Pro2booth was conducted. Participants were asked to estimate the time they spent using the tool on each day, complete a systems usability survey (SUS)[2] as well as a series of qualitative questions about their experience using the tool and how it integrated with their design process.
Participants on average spent 16.7 minutes using Pro2booth per day. These times fluctuated through the week with peak prototype generation occurring on day 2, and lowest on day 4. Average time to capture each prototype is 4.6 minutes which is higher than the time measured by Archie. Capture time can be attributed to usability of the tool, number of images/videos captured per prototype and amount of information captured. The high time per prototype could be attributed to the manual nature of picture/video capture and usability issues of the tool. These were commented upon by some participants in the survey - *"it was interruptive in the creative process, and it was difficult to keep overview of the steps after filling it in [sic]"*. Whilst providing disruption some participants commented that *"[Pro2booth] forced me to record things I wouldn't usually have saved"*. This highlights an important tension in that whilst capturing prototyping processes does create a valuable record on design activities carried out, it will disrupt creative processes. Finding a happy medium here is therefore crucial.

5.2. Reflections on the IDEA challenge

Reflections on the IDEA challenge provide insights on whether partaking in a hackathon such as this is worthwhile for the participants. This is an important consideration for the implementation of design studies (gathering participants) and fostering community - which was one of the primary goals of the IDEA challenge. Quantitative and qualitative feedback was gathered from participants via means of a survey. All participants indicate they would like to be contacted or involved with the future of the IDEA challenge. The results of quantitative survey questions are shown in Figure 4. The responses indicate that the vaccine distribution challenge was appropriate, the challenge was enjoyed and that participants would partake in a subsequent IDEA challenge and recommend others to do so to.
Tensions can be observed in the length of time of the challenge. Whilst it was considered appropriate, some participants did feel it took too much time out of their day to day. Participants also generally found the virtual hosting engaging, though would have preferred the challenge to have been hosted in person. Participants also generally enjoyed meeting other engineering design researchers. These points will be considered in the discussion section where recommendations for future hackathons will be made. To support the quantitative results, qualitative questions considered what was good, what was bad and what could be improved about IDEA.
Positive remarks in response to what was good about the IDEA challenge concerned the appropriateness of the challenge and the structure and organisation of the event overall. Many participants also appreciated the opportunity to get out of their home working routine and considered it a great team building opportunity. Some examples of participant feedback showing this include:

- *"Good challenge. I liked the points and ranking system, made it more exciting and encouraging. I liked also the kick-off each morning, to see what the other teams have been up to."*
- *"The topic was interesting and was really fun to have a challenge where we had to apply the things we teach and research. The four-day format was good. It was interesting to compare our skills with other labs from Europe."*

[2] SUS results are detailed in a separate publication.

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- *"Appropriate project scope for the time we had. Fun to work together with other lab-mates on this project, I don't get to do that too often. Nice to meet other researchers, even though it was only on teams."*
- *"I liked getting out of the day-to-day work and using my brain to focus on one problem to solve together. It was good to work together as a team on location instead of the working from home situation in the Netherlands (it was a very nice break!). The challenge was connected to what was happening in the world so it felt like we could actually help work this out."*

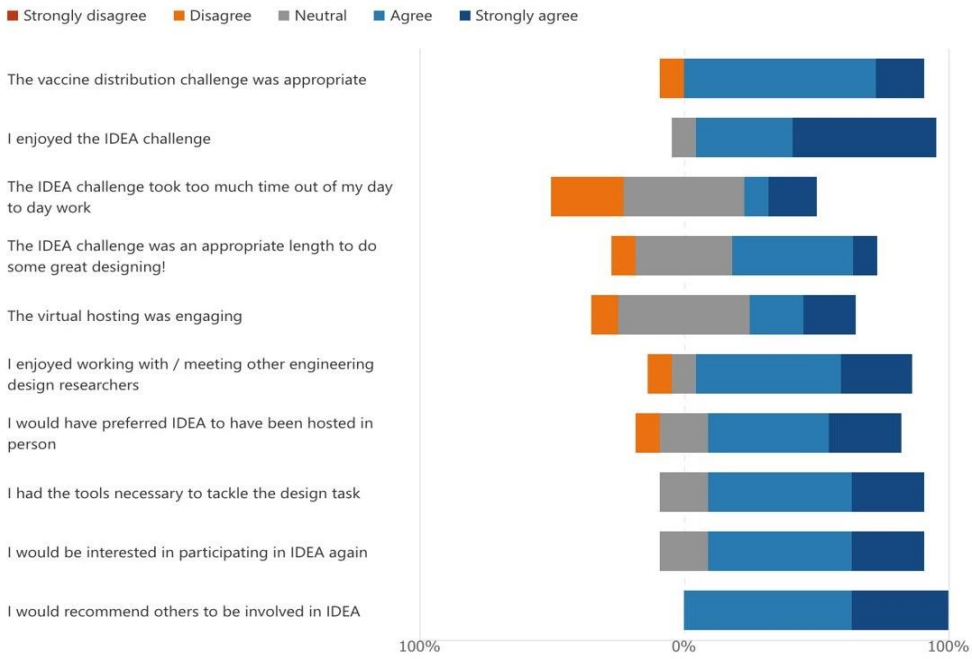

Figure 4. Quantitative participant feedback

A number of areas were identified by participants as being ***disliked*** or that they ***could be improved***. Participants wanted more networking opportunities and more interaction with the event organisers to discuss their progress in the hackathon. These could have been social events, such as an online escape room. As organisers, we were surprised by this as when setting the hackathon schedule, we were wary of *zooming out* participants with too much online interaction. Participants also suggested providing material lists of the materials required in advance of the challenge and would have liked requirements of design outputs (e.g. daily) to be more prescriptive. Both of these elements were not carried out for the challenge due to uncertainty around what tools and facilities each group would have available to them, as such we kept the challenge open and adaptable to make sure all outcomes could be accommodated for. In addition to this, prescriptive design outputs were not conveyed to teams due to the nature of the design study being carried out - we wanted to see how teams worked independent of instruction. On reflection, this should have been made clear to the teams so they didn't think they might be doing the wrong thing. In survey responses, a number of participants suggested they would have preferred the challenge to be hosted in person as this would have been more engaging and would have provided more opportunities for networking.

6. Discussion & further work

The first instantiation of the IDEA challenge met the goals set out but with areas identified for improvement. A large (200+ prototypes), rich (1300+ connections) prototyping dataset was generated, demonstrating that the IDEA challenge and associated design study were able to generate design research data in a virtually hosted hackathon. The dataset broadly captures the product (i.e. prototype form, behaviour, and evolution thereof between versions), process (prototyping activities, tasks, dependencies), and people (designers) involved at each stage of the prototyping process, and captures associated design rationale. It is substantial in size and directly representative of the activity that

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occurred, therefore providing scope for a range of research insights. It could be used to appraise affordances of prototyping strategies, permitting elucidation of which methods are used when and why. It is also possible to identify if prototyping strategies impact performance of design outputs. Future research questions applying the methods will consider if early physical prototyping correlates with improved performance of design outputs. It would also enable correlation of designer experience and prototyping strategy. This would be of particular interest if studies compared industrial vs. academic teams. It is of note that the capture methods in current form are manual (i.e. require designer input), and that structure of data captured could be broadened and refined to ensure wide and robust capture across further facets of prototyping activity, such as context, project, and team structure.
From qualitative evaluation of participants, the hackathon was found by participants to be a good way to interact with researchers from other universities and team-build within their own research groups.
Some users found the Pro2booth platform obstructive to their design process. Whilst some level of obstruction is inevitable, in hindsight, we could have provided greater guidance as to how users should have used Pro2booth in order to support rather than hinder their design process. For future IDEA challenges, more guidance will be provided to ensure the platform has a positive design impact. This will likely be in the form of walk-through videos and will be implemented for the IDEA challenge 2022.

A number of recommendations can be made about the running of hackathons as design studies:

1. **It is important that the design challenges proposed is engaging, socially motivated and realistic.** This ensures motivation of participants, and also increases how representative the data is of real-world design practice.
2. **Gamification and scoring real time (e.g. daily) of teams is beneficial.** It is valuable for keeping teams motivated and engaged (as found in survey) and also results in all text fields be completed.
3. **Provide networking and socialising opportunities for participants.**

Two key tensions can be observed in running hackathons as design study regarding data capture and virtual vs**.** in person hosting respectively. Lightweight data capture is crucial in order to not interfere with design processes; however, data richness or completeness is essential to enable characterisation of design activity. This trade-off needs to be managed appropriately in accordance with research aims. ***Following the success of the inaugural IDEA challenge***, the IDEA challenge 2022 will be hosted collaboratively by the University of Bristol and the Norwegian University of Science and Technology will run for 4 days in April. The general structure of the hackathon will remain the same with virtual hosting as this was deemed to be beneficial for the design study (as teams worked fully independently) and logistically more straightforward in terms of finding appropriate spaces. Changes from the first challenge will include increased networking events, such as pre-event discussions that will seek to create research working groups. Required materials will be defined in advance and either sent directly to teams physically or as a shopping list. The design task will also be more prescriptive with respect to what needs to be delivered. Or, if the design study requires this to be left open, the openness will be made explicit to teams. In addition to the organisation and running of the IDEA challenge 2022 an additional avenue of further work lies in the analysis of the current dataset to better understand designers' use of prototypes in hackathons with particular attention to the affordances of physical and digital prototypes. The dataset generated during the challenge and subsequent network analysis undertaken (Kent *et al.*, 2022) will facilitate the generation of visualisations that could be used to provide feedback to designers in real time during a design activity such as a hackathon.

7. Conclusion

The aim of this paper was to explore how to capture useful design research data about hackathons hosted virtually. This was achieved through detailing the organisation, instantiation and appraisal of the IDEA challenge - a virtually hosted hackathon - along with the implementation of a prototype capture tool and its associated design study. The hackathon and study were shown to be successful in the gathering of design research data through the generation of a dataset of over 200 prototypes by 4 design teams during the hackathon which provide rich insights into design activity at these events with regard to product, processes and people. Recommendations are provided for future instances of

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hackathons as design research studies. These include ensuring a realistic design challenge, using real time scoring and providing networking opportunities for participants.

Acknowledgements and dataset

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