# Simulations in Service Design Prototyping

## *Drone Deliveries with Society-in-the-Loop*

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This research-through-design study explores how computer simulations of drone delivery traffic can be used in service design. It investigates how computer simulations compared to a desktop walkthrough can inform the design, and how simulations can be used to facilitate a citizen perspective in service design. A workshop where participants evaluated a simulation of the drone delivery service was compared to a workshop where the participants took part in a desktop walkthrough. The results showed that the participants discussed many of the same aspects, but there was a difference in the perspectives taken. The participants using the simulation took more of a community perspective and discussed dystopian risks, and they also used the simulation to compare distance and speed. The participants in the desktop walkthrough, took more of a customer perspective and a technology perspective. It is concluded that the simulation helped participants gain common ground of dynamic aspects of intense drone traffic, and that the aerial view lifted the perspective from the service encounters and service users to that of the surrounding society.

Keywords: service design; prototype; simulation; desktop walkthrough; drones

## Introduction

A future drone delivery service would affect many people in a city. It is likely that the city government would have a regulatory function in the design of such services. The design would require, not only a dialogue with primary users, but also with citizens to ensure that drones can function with current infrastructure and fit into the lives of citizens. This research-through-design (RtD) study aims to explore how computer simulations can be used for citizen engagement in service design of drone deliveries for students in a Swedish university city.

Simulations used as prototypes can potentially function as a divisible object and facilitate collaborative systemic design efforts. They can work as external representations and as such simplify the exploration of ideas and make it easier to both improve concepts and create new ones (Bjørndahl et al., 2019; Kirsh, 2010). Different prototypes are however good at conveying different things (Johansson & Arvola, 2007). For the purposes of this paper, we employ a broad definition and take prototypes to mean manifestations of design ideas of different materials, scope, and fidelity that filter some aspects of the design (e.g., appearance, data, functionality, interactivity, structure), and they can serve the purpose of evaluation; exploration of user experience, needs, and values; generation of ideas; and/or communication between the participants of a workshop (Lim et al., 2008). The fidelity of a prototype can affect participants' assessment of the design (Rudd et al., 1996; Walker et al., 2002).

Simulations can offer a safe way to test a system before it is implemented (Thompson et al., 2008). Simulations in service design is a relatively unexplored area, but they have the potential to visualize multiple simultaneous events with multiple agents and dynamic processes which can be useful in all systems design (Bubna et al., 2019; Caglayan & Afacan, 2021; Lundberg, et al., 2018). There are few studies on how simulations can be used in service design in comparison to commonly used service design prototyping methods. One such method is the desktop walkthrough where participants visualize service concepts by play acting different scenarios in a miniature world (Blomkvist et al., 2016; Blomkvist & Wahlman, 2018). The research questions for this paper are therefore how computer simulations can be used for citizen engagement in the evaluation of drone delivery services for students in a university city, and how such computer simulations can inform the design process in comparison to a desktop walkthrough.

Systemic design typically involves transitions between levels of understanding, from that of physical objects and manifestations, to an understanding of how that affects higher-level values such as safety and privacy. Or vice versa, from a concern for privacy, to assessment of a particular situation. In our work, we have previously used a framework for this that includes six levels (Lundberg & Johansson, 2021; Lundberg, et al., 2018): (1) The particular objects, their status, and what they convey; (2) the objects-in-motion and the properties they gain in use; (3) generic recurring patterns of, for example, movement; (4) generic qualities and trade-offs of services, such as the level of noise that is usually generated by a particular service at a particular place and time of day, versus its societal value; (5) effect goals; and (6) a framing of what goes on, as for example a delivery of a service, a drone that might take photos as it passes over my house, or a drone that might fall down on me as I walk beneath it. The first two levels regard the more physically manifest how of a service. The third and fourth level is a more abstract what. Finally, level 5 and 6 concerns the subjective why of the service, including goals that people have and how they view situations.

## Research Method

The study builds on a research-through-design (RtD) approach, which means that design practice and the creation of some artefact is central to the knowledge generation (Stappers & Giaccardi, 2017). The artifact in this study was a drone service for food delivery for students in a university city. This case is instrumental to the investigation of the use of computer simulations of drone traffic in two workshops in comparison to a desktop walkthrough in two other workshops. Excerpts of the audio and video recorded workshop conversations that could be directly related to the simulation or directly related to the desktop walkthrough representations were transcribed in verbatim and analysed using reflexive thematic analysis (Braun & Clarke, 2006; 2019). The first author did the analysis to investigate the discussions that the participants had around the prototypes. The analysis was data-driven and only the explicitly expressed was coded, not underlying assumptions. The analysis had the following steps after the verbatim transcription: (1) Familiarizing with the data by reading and re-reading the material to find patterns; (2) creating codes that fit identified patterns; (3) generating themes from the codes; (4) placing relevant data under each code while also adjusting and refining codes and themes. Writing and analysis took place in parallel. The results are presented with the strongest examples from each theme, translated from Swedish once the process was complete.

The drones service under design had the purpose of delivering fast-food. The design was driven by divergent sketching and the three most promising concepts were chosen for elaboration. One concept was then chosen based on a requirement inspection. A service blueprint, a storyboard, and an assumed persona was created to illustrate the service for the participants in all workshops. These are described elsewhere (Böhm, 2020). The storyboard used as introduction for all sessions is shown in Figure 1.


Figure 1. The storyboard that illustrated a scenario of use in the workshops.

Thirteen participants aged 24–32 were recruited by convenience sampling. There were six participants split into two in the workshops with the simulation and seven participants split into two workshops with desktop walkthrough. Informed consent was given by the participants. LEGO and drawn physical locations were used as material in the desktop walkthrough workshops (Figure 2).

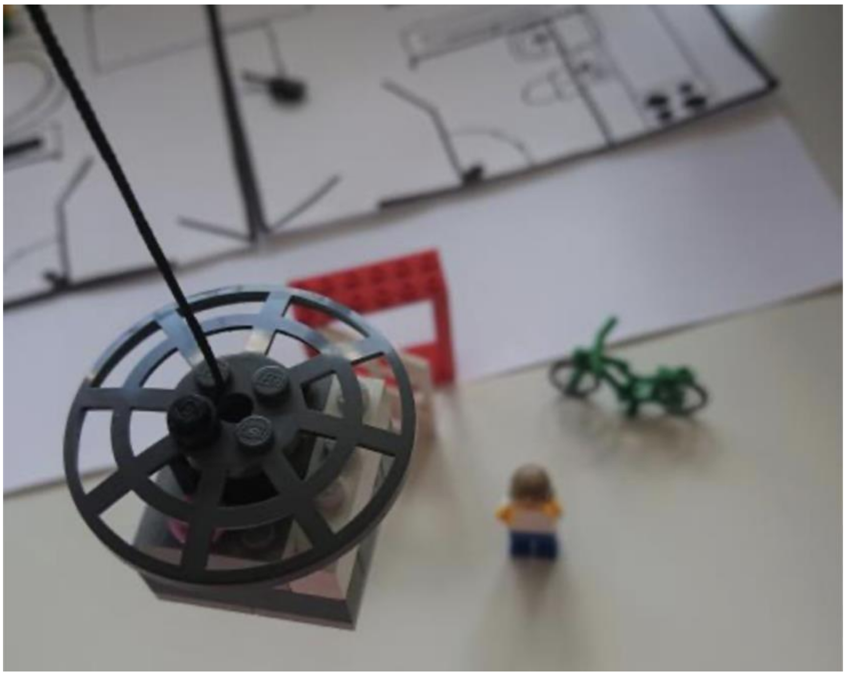

Figure 2. Staging of desktop walkthrough where a drone lands at a customer's home.

The drone traffic simulation (Lundberg, et al, 2018) used in the simulation workshops implemented two services that delivered fast-food from one point to an area in town. The participants could see the drone flying across an aerial view over the city (Figure 3). The number of drones in the air could be adjusted and it was also possible to create areas where the drones were not allowed to fly. Five scenarios of use were discussed in each workshop: Order food from home; the neighbour orders food at the same time; the food is delivered to drop-off point down the street; the food is dropped down by a wire from the drone; and many want to order food on New Year's Day.

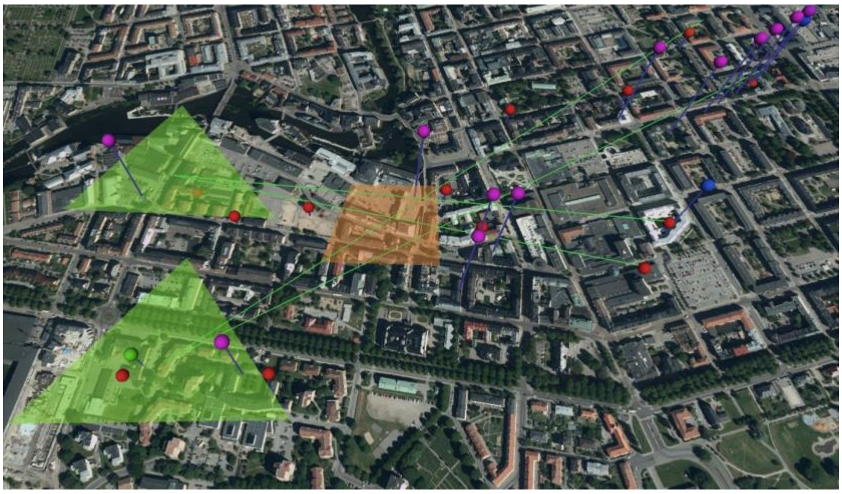

Figure 3. Screen capture from the simulation. Background generated from GSD-Ortofoto25 and GSD-Höjddata, grid 2+ © Lantmäteriet.

## Results

The reflexive thematic analysis produced four themes: customer perspective; restaurant perspective; technology perspective; and societal perspective. A comprehensive account is reported elsewhere (Böhm, 2020).

### Customer Perspective

The customer perspective covered the sub-themes of delivery, alternative deliveries, uncontrollable variables, and accessibility and ergonomics. Overall, the participants saw many customer experience problems and risks in relation to the delivery, such as theft, weather, and queuing. The discussions in this theme showed how it came naturally for the simulation participants to use the simulation to determine speed and distance and to specifically mark locations in the aerial view. One participant said:

*It feels like it could have gone faster. Just because the bridge there is rather cumbersome, and if there's a lot of up-hill and down-hill, which it is there, then you often must bike.*

This means that they could contribute with quite specific considerations on, for example, delivery locations, especially if they were familiar with the city.

Desktop walkthrough participants instead discussed how the delivery might be done in more detail, and sometimes thought of possible solutions to the problems they find. The desktop walkthrough seemed to facilitate discussions about accessibility and ergonomics, which was not discussed at all in the simulation workshops. The participants in the desktop walkthroughs used the LEGO pieces to stage, play act, and visualize various issues, such as instability and weather problems:

*Yes, it will then be more like this (shows how the pizza is lowered using a wire while it spins) Yeah, here it comes on a wire and just rotates like this and then like 'oh thanks, all the ingredients on the pizza are in a corner.'*

### Restaurant Perspective

The restaurant perspective comprised the sub-themes of changes for the restaurants and potential problems for them. Both prototype groups captured a solution with delivery rounds where one drone flew to several addresses, which could save time and money for the restaurants if the restaurants have their own drones, as illustrated in the following excerpt from the simulation workshop:

*But is it… It's now like a simple point A to point B and then back. But I think if you start adding… all these that have ordered food to different times on the root, then the drone gets to go in a rout around. I think, it becomes more of a delivery truck thing. They will like deliver more than one thing and then go back to the home station.*

The desktop walkthrough participants found several potential problems and they were in some cases solution oriented, as in the following excerpt:

*D1: Or is it FASTer FOOD support that manages and fixes the drone stuff. I think that this is very complicated because like…*
*D2: So this is some kind or air traffic control centre? (Points to the customer support that they built.)*
*D1: Yeah, remote air traffic control of drones sort of.*
*D3: So there might be cameras here by the door that they have access to.*

They considered how the restaurant would need to be designed to work systematically with the drone delivery service. If the restaurants would have to be retrofitted and remodelled for the service to work, it will be difficult for most restaurants. Solutions that do not require retrofitting would therefore need to be considered. Another thing they discussed was mistyping the address, which could quite easily happen.

## Technology Perspective

The technology perspective included the sub-themes of functionality, automation, and crime prevention, as in the excerpt below from the desktop walkthrough:

*D1: [The door opening] is either automatic and then anyone can catch a drone and go there and get all drones, because it opens automatically from the outside too. Or they would also have to press and then then they will have drones outside hovering outside and waiting to get in until someone presses and opens.*
*[…]*
*D2: But, it can be it can be (…) a sensor above. That they must open the garage door to (…) let in, but (…) when it's outside it can be a sensor that automatically opens always to let drones in.*

The participants in the simulation workshops discussed for example solar energy, risk of collisions, and accidents, as in the following excerpt:

*D1: [It] doesn't feel possible to avoid accidents either. There will be crashes in some ways.*
*D2: They crash and then fall down on people or make damages to property.*
*[…]*
*D3: They will run out of, I don't know, batteries. So (…) some will surely get problems and stay there after someone has taken the pizza out since it doesn't understand like that it should go back. And then there are these things everywhere. And (…) what if it crashes and one of these goes into the water or in the street and risks harming people.*

It is possible that these considerations were facilitated by the simulation that visualized many drones on the screen. There seemed to be a lack of knowledge among the workshop participants about how the drones work and what kind of technologies would have been possible to use.

## Societal Perspective

The societal perspective covered the sub-themes of attitudes, impact on society, future considerations, and air traffic. This perspective was only present in the simulation workshops, and this appears therefore to be something facilitated by this prototyping method. Seeing the drones from above and being able to see several deliveries at the same time, together with the aerial view, seems to have facilitated on how larger society would be affected by the drone delivery service, as in the following excerpt:

*D1: And that it becomes like, I'm thinking about trash, or like the environment and stuff. It'll be like you think you're gonna be bothered and think that it's like, not as pretty. I'm not sure how to explain it. That it feels…*
*Facilitator: Messy?*
*D1: Yes.*
*[…]*
*D1: I think that I would have been really bothered (…) if you like centrally and there's things going on everywhere. Suddenly, it's above you as well.*

The participants also discussed it in terms of a dystopia and in terms of surveillance:

*I can imagine that you would have been a little annoyed and think that if you had a house in this where you had worked because you feel that "I shouldn't have anyone looking into my home" like hedges and stuff, and then it starts flying above you all the time. (...) You would just (...) have felt under more surveillance. Even if there hadn't been any camera or anything. [...] It's just this "Big Brother watches" thing. Even though that's not the purpose, but (...) think of China.*

## Synthesis

Figure 4 illustrates the proportion of discussions spent on different themes. The figure shows several differences between the two different prototypes where the societal perspective was dominated by the simulation groups, while the desktop walkthrough groups had more conversations with a customer perspective, but also a little more restaurant perspective and technology perspective.

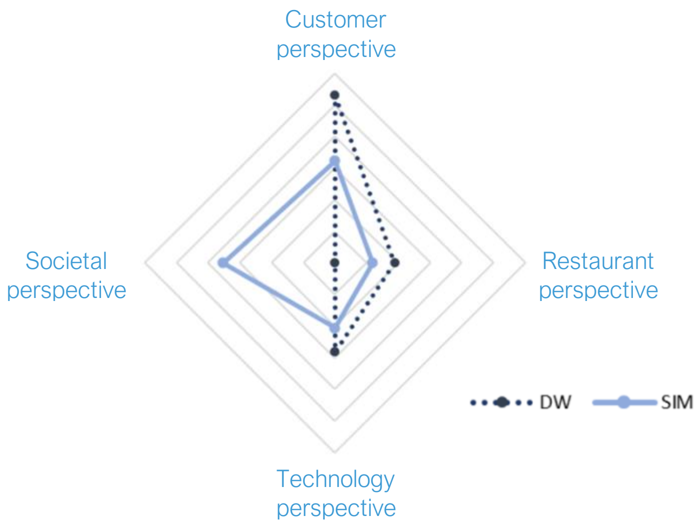


Figure 4. Visualization of how much the different prototype groups, desktop walkthrough (DW) and simulation (SIM), discussed different themes. The figure does not represent any exact frequencies of utterances.

Based on the discussions that took place in the different groups, an analysis was also made of which filtering dimensions (Lim et al., 2008) the different prototypes had. This is illustrated in Figure 5.


Figure 5. Visualization of the filtering dimensions of the desktop walkthrough (DW) and the simulation (SIM). The figure does not represent any exact frequencies of utterances.

Appearance, refer to the appearance of the drones themselves, as well as how drone swarms would be perceived from the ground (e.g., it would look "messy"). Interactivity refers to how people interact with different sub-systems (e.g., feedback, input, operations, output). Functionality refers to the functions that are performed by the designed system. Two of the dimensions (Lim et al., 2008), data and spatial structure, were not touched upon at all and are therefore not included in the figure. The figure shows that there was no major difference in the filtering dimensions between the desktop walkthrough and the simulation. The participants in the simulation workshops discussed a little more about the appearance of the service and a little less about the interactivity.

## Discussion

The analysis of the data generated four themes: customer perspective, societal perspective, restaurant perspective, and technology perspective. These four themes are not exclusive but reflect the data from the workshops with the students (other stakeholders would likely have given rise to other themes, such as political and regulatory). The major difference between the two prototype groups was that only the simulation had discussions from a societal perspective. This directed the participants towards talking about both air traffic control (i.e., where drones should not be permitted) and the fear of a surveillance society due to cameras on the drones, both important to reduce the risk that the service evokes negative emotions. The participants in the simulation group thought of it as a dystopian future. The simulation shows an aerial view where several parts of the city can be seen at the same time, and this might have contributed to discussions of societal aspects as well as discussions about distances and particular places such as delivery points. The desktop walkthrough participants probably had a harder time visualizing that many drones in the air and therefore did not reflect as much on this. Instead, they used the physical external representations (Bjørndahl et al., 2019; Kirsh, 2010) in the form of LEGO to talk about how the food would be delivered and received, both by people at the restaurants that sent food and customers that received food. These discussions involved issues regarding which type of sensors the drones had, in addition to ergonomics and interaction, including how it would be received by customers in wheelchairs. This was a perspective that was absent in the groups that used the simulation.

Although the groups in many cases talked about the same things, they discussed them from different perspectives. An example of this is the conversations about queuing, a problem that could occur if several customers living nearby each other orders at the same time. Unlike the desktop walkthrough groups, which discussed this from a customer perspective where the customer would have to wait a long time for the food, the simulation participants talked more about how the traffic would need to be directed so that all drones could get there. This cannot be a result of the professional look of the simulation compared to the Lego builds in the desktop walkthrough. These results are in line with previous research that shows that different prototyping methods are good at conveying different aspects (Johansson & Arvola, 2007) and that it is an advantage that simulations can simulate several events simultaneously (Bubna et al., 2019).

The simulation with its aerial view grounds the discussions in a different way than the desktop walkthrough, based on what is objectively visible and subjectively seen. The aerial view proposes a perspective of the city, rather than a specific location of, for example, receiving a package. This widens the context (or system boundary) of the service, to see how others are potentially affected by it, through its journey from start to landing. Furthermore, the simulation supports imagining things that are difficult to imagine, such as how fast the drones will move, how many drones there will be, for how long drones will be active in an area et cetera. The simulation also routes the drones, for example around geofenced areas, showing where there will be something alike a highway in the sky. The aerial view shows what the drones will pass over, such as roads, parks, and buildings. This provides a means for building empathy, that is, to try to understand how it would be for others, or for oneself, at places on the ground, or in various roles (e.g., as a traffic controller).

Turning to the question of the levels of understanding, from physical objects to overarching goals and frames (Lundberg & Johansson, 2021: Lundberg, et al., 2018), we can discern important nodes of variation in the system under design. The first is the variation in services. What services that are implemented affect not only drone traffic patterns, but also the service users and as well as service non-users. The second is variation in framing. People of different professional and personal backgrounds make different framing of the service, the traffic, associated values, and goals. Given this, although the participants in this study got ideas about the traffic, people with professional training will most likely see other things, for instance if they have backgrounds in air space safety, regulation, urban planning, or running services using other transport modalities. Furthermore, personal knowledge of the places involved can enrich discussions. This can highlight personal goals and values related to the particular places and individuals. We call this engagement of people who are not particular customers or users or operators “society-in-the-loop”. For service design, “society” is a counterweight (or perhaps in some cases an amplifier) to the desirability of the service for a “user” group.

Another variation in the system under design that the simulation could compute and visualize are the things that are somewhat abstract such as “noise” or “risk of x” (where x could be for instance that a drone fails and drops gently to the ground in a parachute or that it disintegrates by design during a hardware failure and small pieces are spread in the wind). This would add things to the accumulation of observable common ground, to which participants could bring their own viewpoints. Selecting what to bring into such visualizations is an important issue in the design of services. The understanding of objects and their use (a set of drones that flies “here”) and consequences for higher level goals and values (e.g., how much noise do they make, how much they impede on privacy, how likely are they to collide) can be hard to assess without expert knowledge. Such assessments could be encoded and visualized dynamically as the simulation is explored.

There were major differences between the two types of workshops that cannot be attributed to the filtering dimensions (Lim et al., 2008) of the prototypes. The discussions in each workshop touched upon three of the five filtering dimensions: appearance, interactivity, functionality, data and spatial structure. Appearance refers to the appearance of the product or system, interactivity means how people interact with different sub-systems, functionality refers to the functions that are performed by the designed system, data means the type of data used in the system or how it’s organized and spatial structure refers to the arrangement of the interface or other information elements. Both the simulation and the desktop walkthrough facilitated discussion of interactivity, functionality, and appearance (not data and spatial structure). The difference between the workshop types was instead in the perspectives that the prototypes facilitated the participants to take (customer perspective, societal perspective, restaurant perspective, and technology perspective), indicating that the filtering dimensions cannot by themselves explain the differences in the discussions. Adding perspectives to the theoretical model of Lim et al. would make it more nuanced. As in previous studies (Walker et al., 2002), we can see that both the desktop walkthrough prototype with low real fidelity and the simulation one with high fidelity could contribute to the evaluation of the service design. However, different issues were identified depending on which prototype that was used, and these relates to the perspectives that the prototypes facilitated. Besides this, the simulation and visualization could also facilitate a record keeping of such explorations and discussions. If experiences and views of workshop participants could be encoded back into the visualization, then it could become a rich repository of viewpoints (to the extent that people can unpack what is encoded). A first step could be that the services that were explored in a session can be saved and brought back in new sessions. However, more of the discussions must also be represented, to also bring back echoes of the discussions that took place (e.g., frames, goals, values).

Earlier research has shown that simulations are advantageous to use in service design to represent simultaneous events (Bubna et al., 2019). By also seeing the service from a macro perspective as in the aerial view of our simulation, more societal aspects could be explored, and thus more societal problems could be discovered at an early stage. Different kinds of simulations, providing different filters (Lim et al., 2008) on the design might be suitable for different stages of the design process. A hypothesis based on earlier research would be that prototypes with lower fidelity, like a desktop walkthrough, fit better in an earlier concept stage, while prototypes with higher fidelity, like a simulation fit better at a later design stage (Rudd et al., 1996). However, our results do not support such a hypothesis, and consultation with citizens should take place relatively early so that they have a lot of opportunity for input. This discrepancy deserves further attention in future research.

## Conclusion

The computer simulation in this study was used for citizen engagement in service design and provided a societal perspective and multiple stakeholder’s perspectives (both customer and restaurant in this case). The desktop walkthrough participants did not discuss the service from a societal perspective. Instead, they took primarily stakeholder perspectives and talked also about the technology in more detail, including ergonomics and accessibility issues. We conclude that the simulation was useful for society-in-the-loop design and communication on how and where drones may fly and where possible delivery points should be located. The simulation was not appropriate for discussions on details of ergonomics and interaction between stakeholders and between stakeholders and the drones. Therefore, the simulation worked best with one or more complementary prototypes. The simulation in this case broadened the perspective to non-users of the service. Thus, it serves as a means of empathy to other stakeholders, who may have a (sometimes decisive) say in the realization of the service. It is thus an important counterweight to focusing on the service encounters and the service users. The simulation made it possible to get a common visual point of reference also for dynamic aspects, like movement and speed, that might be hard to collectively imagine in the same way. We also identified avenues of future work into the use of this hybrid prototyping approach: (a) To use it with a varied base of stakeholders diverging in terms of framing, goals, and values; (b) to use it with people with particular experiences of the particular places involved; (c) to visualize particular values connected to the traffic (e.g., noise, risk levels); and (d) to vary the kinds of services involved (also changing the groups who would potentially be users versus non-user society stakeholders).

## Acknowledgements

This study was funded by the Swedish Transport Administration and the LFV Air Navigation Services of Sweden through the project UTM CITY. We wish to thank all workshop participants for their valuable input to this study.

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