

# Participatory Design Fictions: Supporting Ethical Awareness in the Digitalisation of Smart Cities' Critical Infrastructure

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**Abstract**—This paper investigates participatory design fictions as a method to involve citizens in the digitalisation of smart city critical infrastructures. By this we contribute to the topic raised by the call for papers to ACHI-COCREATE, to investigate how to make processes of digitalisation accessible to everyone. Based on the observations in one workshop organized for this purpose in a project aiming to install digital water meters in a mid-sized Norwegian city, we find that that participatory design fictions show promise in supporting citizen participation and the discussion of ethical considerations of making cities smarter with the help of Information and Communications Technologies (ICT). We find that it is important to prepare design fictions that heed the basics of storytelling as applied in journalism, to make the story both relevant and provoking. Further, we find that if city officials with professional knowledge of the project at hand participates, more rules of engagement and prepping is needed to make sure that they leave enough room for speculation. Even though the citizens participating in the workshop had little knowledge of digital water meters beforehand, the design fictions enabled them to quickly identify ethical concerns with how the data from these could potentially be misused.

*Keywords*- design fiction; smart cities; participatory design.

## I. INTRODUCTION

In the last decades, the development of Information and Communications Technology (ICT) is changing our cities. Machine learning, the Internet of Things (IoT), Artificial Intelligence (AI) are promising to make our cities smarter [1]. From a technology perspective, ‘a smart city is considered a city with a high presence of ICT applied to critical infrastructure components and services’ [2]. The digitalisation of critical infrastructures is opening opportunities for better services for the community and its citizens, but at the same time raises concerns regarding an increased possibility for monitoring and observing citizens’ behaviours. Involving people in discussing issues concerning them is a core democratic value, which should also be at the centre of smart city projects. Citizens do not have a clear picture of the opportunities, challenges, and consequences of introducing smart city technologies. While some benefits are predicted from the start, others take shape in use. It would be in both citizens and local authorities benefit to find ways to discuss how smart city technologies can improve the quality

of living and at the same time negotiate how risks of such infrastructures should be mitigated.

Participatory Design (PD) is a field of research which investigates how users' can be involved in the design of technologies meant for them [3]. PD has promoted citizens' genuine participation in the discussion, design, and envisioning of new ICT solutions and services. By involving citizens and giving them a voice, local authorities can make environments and technologies more useful and useable. To this end, Ruiz presents a participatory governance model aiming to establish a sustainable development path for the design and implementation of public services delivered through IoT in smart cities [4]. Bratteteig and Wagner discuss how citizens have been involved in design activities for urban planning [5]. There is a lack of studies, however, regarding citizens' involvement in discussing possible upgrades in critical infrastructures to achieve smarter cities. Thus, in this paper, we present a study of using a PD approach, utilizing design fictions, to enable citizens in the discussion of digitalizing of critical infrastructure – more specifically, the water supply system. By this, we contribute to the topic raised by the call for papers to ACHI-COCREATE, to investigate how to make processes of digitalisation accessible to everyone.

In the following, we initially present the theoretical grounds for this work. Then, we describe the case and present our findings concerning citizens participation in the workshop. After a discussion of these findings, we conclude by offering some valuable insights on the use of participatory design fictions to reinforce smart city initiatives that strive to digitally transform critical infrastructures in a responsible and empathetic manner.

## II. THEORY

To ground the work theoretically, we initially need to clarify how we conceptualize Critical Infrastructure (CI). CI is a common term used at the political level to refer to lifeline systems, which greatly influence public welfare and economic prosperity [6]. CI's include energy, telecommunication and ICT networks, water, food and agriculture, healthcare and public health, financial systems, civil administration, public, legal order and safety, national monuments and icons, commercial facilities, critical manufacturing, and the defence industry base [7].

Decision making in governing CI's has been the domain of policy makers and within governmental settings [8]. We argue that citizens should be involved in the discussion of evolving CI's and by this raise ethical considerations and awareness in the population [9]. In rich and democratic countries, the legal right of access to government information based on openness and accountability has been established decades ago, but sometimes such rights are eclipsed in favour of competing government interests [10]. The involvement of citizens in the development of CIs has been mostly explored in relation to the concept of smart cities. Smart cities have been defined as cities that promote the digitalisation of CIs to improve citizens quality of life. According to Albino et al. [1], the main themes that has been addressed when citizens has been involved in the design of CIs for smart cities is management of common resources [8], environmental awareness and sustainability [11], safety and privacy [11]–[13].

#### A. Participatory Design

PD is an approach that provides a framework for technology development with a focus on securing participation from all involved parties in all parts of the process [12]. PD stands by a set of principles that define the field [13]. A core principle is to secure democratic practices by equalizing power and to give everyone a voice. Another one is to foster mutual learning in building new knowledge and values by finding ways of working that emphasize engagement, expressiveness, negotiation, and problem solving. An aim in this is to support the co-creation of alternative visions or future scenarios involving the technologies and services addressed. To enable mutual learning and envisioning alternatives, adequate tools and techniques are needed. PD can be described as a family of design practices that come with a variety of toolboxes. Tools and techniques are commonly adapted, combined and extended and should be appropriated to the design [14]. In the case of involvement of citizens in developing CI's, the principle of mutual learning and building alternative visions becomes particularly challenging. Thus, we investigate how participatory design fiction could enable citizens to actively participate in the process.

#### B. Participatory Design Fiction

In PD, scenario based techniques are commonly used. Brandt et al. [14] discuss the role that scenario-based design has in enabling envisioning future alternatives as well as in reflection and learning [15]. Using storytelling and critical design as resources, design fiction is a design practice that aims to explore and critique possible futures [14] by creating speculative and often provocative scenarios told using designed objects. It is a way of facilitating and promoting debates as explained by the futurist Scott Smith: '... design fiction as a communication and social object creates interactions and dialogues around futures that were missing before. It helps make it real enough for people that you can have a meaningful conversation with' [15]. Design fiction has been used in PD for enabling participants engagement when it comes to cases of complex technologies [16], [17] or

vulnerable user groups [18], [19]. Design fiction is built on fictional stories that represent the creation and construction of possible future worlds, in relation to the actual world [20] and they present possible worlds that have specific accessibility criteria [21].

Muller and Liao [16] have categorised four types of design fiction that can be employed in PD to envision future AI technologies.

- Fictions as probes to elicit user needs by asking questions to users regarding values they perceive in the story or experience.
- Fictions as theatre where users are encouraged to change the story to critique and change a proposed user experience.
- Fictions as participatory constructions where users are encouraged to write the stories themselves by introducing a narrative transformation.
- Fictions as group co-creations where the users are encouraged as a group to engage in hands on activities that contribute to co-creation of stories.

In the following, we explore design fictions that combine elements of all four of these categories, attesting to the dynamic, malleable, and playful properties of the method. The emphasis in our case will be design fictions as a door opener to democratic, open, and emergent discussions of digitalizing CIs in smart city projects.

### III. METHOD

In the following, we will describe how we have collected and analysed data from a workshop organized to shed light on how participatory design fictions can be used to involve citizens in the development of CIs. The workshop was part of a larger project aiming to install water meters with real-time data sensors in every household in a mid-sized city in Norway, to monitor, regulate and tax water consumption (the smart water project). The outcomes of the increased visibility of water consumption on the level of individual households may be positive or negative for citizens, but until this study, they had not been involved in the discussion. The aim of our research was to give the citizens a voice and a chance to be heard, regarding the further digitalisation of the city's water system. The local authorities were interested in understanding the citizens' perspectives on the potential opportunities and threats presented by the installation of such water meters and welcomed the research initiative. They valued the opportunity to go beyond traditional methods like surveys and focus groups, to enable genuine, comprehensive, and accountable citizen involvement in the project.

The workshop brought together citizens and key stakeholders from the city administration who had expertise in the smart water project. Design fictions were created to raise the three key themes related to smart city development, as presented in the literature: safety, sustainability, and privacy. The workshop was organised by a team consisting of a representative from the city, an expert in the field of water infrastructure and digitalisation and three PD experts (the authors of this paper). To ensure broad citizen participation in the workshop, the city issued an open call on their website

promising a compensation of 500 NOK for participating in the workshop. The call was designed to reach a diverse cross-section of the population, and citizens were asked to provide information on their age, gender, education level, and area of residence. This helped us select a group that represented the city's population and ensured that multiple perspectives were included in the workshop. In total, 19 citizens responded to the call. Based on the inclusion criteria and a first come first served approach, we selected 12 participants who met the desired demographic characteristics.

The workshop lasted for 1,5 hours and the participants were divided into three groups. Each group was seated at a round table together with a representative from the city with expert knowledge related to the smart water project (see in Figure 4). Participants were equipped with printed materials and one of the PD experts moderated the workshop by guiding the groups through the design fiction scenarios. We collected audio recordings from each table and all the material outputs made. While city experts and citizens participated in the workshop, representing different perspectives in the project, the PD experts took the role of PD facilitators, preparing and moderating the workshop.

To analyse the data collected during the workshop, we conducted an inductive thematic analysis of the audio recordings and the created outputs individually. Afterwards, we discussed and compared our coding of the data related to each category. We identified recurring themes and patterns in the data to gain a deeper understanding of the perspectives and experiences of the workshop participants. We developed thematic maps [22] for each category and discrepancies in the coding were discussed and resolved. To ensure anonymity, the groups' voice recordings were assigned pseudonyms, as detailed in Table 1.

TABLE I. PARTICIPANT PSEUDONYMS USED FOR CODING

Group One	Group Two	Group Three
Roger (expert)	Hans (expert)	Camilla (expert)
Per	Odd	Lise
Leif	Anne	Gunhild
Trine	Kari	Ahmed

A. Design Fiction in practice

In the workshop, participants explored three main themes, as suggested by Albino et al. [1], in our case, related to the introduction of digital water meters:

- *Security*: The data generated from digital water meters can help citizens to increase the safety of their households by controlling water leaks and misuse.
- *Sustainability*: Water is a shared and scarce resource raising the dilemma of balancing individual water needs with the need of the whole community served by the water system.
- *Privacy*: Water meters can monitor and record detailed data of citizens' water usage. The usage of IoT systems in homes has been discussed closely to security and privacy issues [23]– [25].

The overall aim of the workshop was to raise citizen's awareness of and engagement with these themes by bespoke

design fictions. In the following, we present each fiction with accompanying questions and tasks.

1) Security

This design fiction proposes how monitoring water consumption can provide security for values and property in the city. We tell a story about how a citizen suddenly receives a SMS from the city stating that there probably is a water leak at in their home (shown in Figure 1). The participants get a copy of the SMS and must decide how this should be handled.

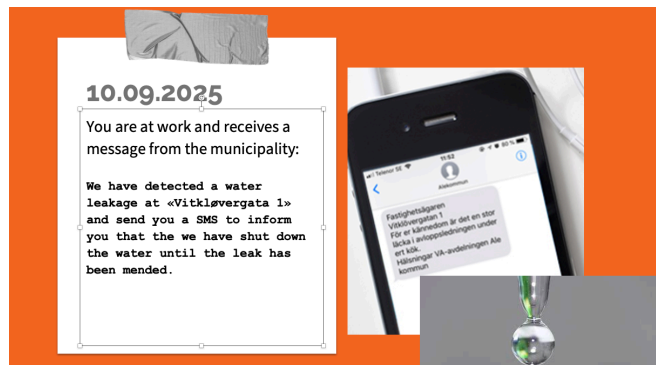


Figure 1. Security design fiction scenario

Questions based on the scenario:

- What should happen if digital water meters detect a water leak?
- Should there be a service so residents can request that the water be turned off?
- How do residents and the city agree that the problem has been solved?
- Complete the sentence: If the digital water meter detects a possible water leakage...

2) Managing scarce resources

This design fiction raises how sustainable water consumption needs to be governed by the city in a situation with severe water shortage during an unusually hot summer (see Figure 2). The participants are issued a "watering fine" by the city and a paper copy of the local regulations. Their challenge is to revise the regulations by removing, modifying, or adding new rules, giving them an opportunity to share their thoughts on sustainability and incorporate them into applicable regulations.

Questions based on the scenario:

- What does it mean to waste water?
- How can digital water meters reduce water use?
- How should the administrative regulations be adapted when new water meters are introduced?

3) Privacy

This design fiction presents a scenario where detailed data from the digital water meters might be misused by the city. A household has been put in a COVID-19 quarantine but due to low water consumption, the city contacts the household by phone to check that the quarantine is being properly observed.



Figure 2. Sustainability design fiction scenario

The participants receive a bill with a detailed overview of the household's water consumption, broken down into days. They are tasked with discussing how this information may possibly be used / misused as illustrated in Figure 3. They can then delete, change, or add to the bill based on what they come up with.

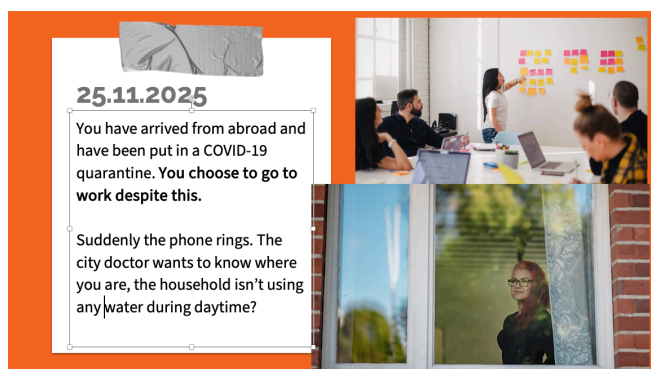


Figure 3. Privacy design fiction scenario

Questions based on the scenario:

- How do you want your data to be handled and stored?
- Who should have access to your data?
- What information are you interested in?
- How may your data be used or misused?

#### IV. RESULTS

The analysis of the sayings and doings of each group participating in the workshop, will inform the further development of participatory design fictions as a method with the potential to secure citizen involvement in the development of critical smart city infrastructures. Further, the analysis reveals insights into how this format gave the citizens support in identifying and discussing ethical concerns with future upgrades of CI's. In the following, we will relate our findings according to how the provided design fictions secured participation and supported the discussion of ethical concerns. To be able to assess the degree of citizen participation we have looked closer at how the groups: came up with ideas, agreed on which ideas were worth promoting, and whether

and how they came up with alternative visions regarding the use of digital water meters that diverged from the ones proposed by the scenarios.



Figure 4. Groups discussing scenarios for sustainable water usage

#### A. Group One

The group came up with few ideas and the expert contributed with most of the answers to the questions worked on. Two of the citizens, Per and Leif, offered some reflections, often on related but somewhat off topics that they were interested in (still concerning water usage). But every time they started discussing the scenarios from their viewpoints, they were broken off by the expert. The repeated breakdowns of the group dialogue led to a lack of engagement from Per and Leif after a while. Trine kept mostly quiet, but engaged a few times, mostly to ask questions. When the time came to prepare the summaries and agreeing on what to promote to the plenary session, the expert reiterated his initial answers and asked whether all agreed, answered by silence or small acknowledgments from the group. To come up with alternative visions regarding the use of digital water in the future, the citizens explored some initial ideas, but were quickly interrupted by the expert. The expert went so far as to undermine scenario three from the outset, saying that it was unrealistic due to current GDPR regulations. He changed his mind after the initial reaction, and tried to initiate and support further discussion, but then the group had lost interest and started looking at their watches.

The group was not able to speculate alternative futures but was able to articulate ethical concerns during the workshop related to all three scenarios. Per and Leif seemed to be acutely aware of questions concerning privacy and wanted full control of the detailed data from the water meters. They wanted to be in the loop when leakage was discovered, receiving a private message (from the meter) and to then get hold of a plumber themselves. Scenario three was therefore rejected by Per and Leif outright due to their privacy concerns. Trine, however, thought the detailed data capture was ok (as represented by the bill), and was less concerned by how the data could be misused. She asked the expert whether she was allowed to take this position. The most engaged discussion was about scenario two, when they considered how

water should be governed in times of scarcity. They couldn't quite decide whether water should be turned off remotely by the city for households overusing water. They seemed to like the idea that overuse was punished fairly, but also indicated some discomfort with the surveillance needed to enforce this.

### B. Group Two

All group members contributed to answering the questions given in the three scenarios and came up with ideas during the workshop. In general, the group was quick to address and discuss the questions asked for each scenario – leading to the expert taking initiative to leave the scenario and interview the group about water meters in general. When it came to agreeing, it was clear that the expert made the final decisions on what could be considered good answers to the questions, recognizable in how he summarized the group's discussions in the plenary sessions. He presented the ideas he had come up with earlier in the discussions – seemingly to reach the other two groups with his reflections and insights. With one exception though, when it came to the idea that house owners should be given a more elaborate consent form or contract when installing water meters – for instance to give the city the rights to turn off the water when detecting a leakage or to give the local health provider access when needed. This suggestion is also an example of how they came up with alternative visions of future use of the water meters, than the ones proposed by the scenarios. Another example is how Anne didn't want to install the new water meter because of fear of radiation (she didn't have an electricity meter either). She gained little understanding from the group, and when suggesting this in the plenary session, the expert in group one explained the concern away. In general, the group didn't speculate too much and kept close to the realities offered by the expert (being the project leader for the smart water project).

As in group one the design fictions raised ethical considerations in the discussions among the group members. Anne was very clear that any unauthorized use of data from the water meters was misuse:

If the head doctor in city had called me and said, where are you? You are not using water! Then I would be extremely pissed! That's surveillance, that must become illegal. #Anne

The rest of the group agreed. She also brought up several times that any data use should be made explicit in a written agreement between the city and the house owner. Further, how the relevant rules and regulations should be made accessible and understandable to all citizens. When it came to using water meters to monitor and restrict water use in times of scarcity, Anne and Kari were open to this use, and didn't really discuss the privacy dilemma raised by this.

### C. Group Three

When it came to coming up with ideas in the group, the expert provided the other participants with information related to the project, that she saw as important to know to be able to discuss the questions. She invited the other participants

to share their opinions and ideas, something all the participants did. They listened to each other's ideas and agreed on a common definition of what it meant to waste water: "If someone wouldn't use the water if they had to pay for it, then they are wasting water". Even if the expert talked the most, the group reached agreement on what the answers to the questions should be. The citizens all participated equally, focusing on different aspects of the scenarios. Gunhild highlighted aspects related to costs. Lise focused on how she would like to get more support in the process and Ahmed saw a possibility for a fairer solution. The expert did a good job to summarize and present the groups opinions and ideas in the plenary sessions, not only her own. The group came up with several alternative down-to-earth visions of future use of the water meters. They thought that it was ok to use water for gardening, but that one should pay for the water. They wished for more support from the city resolving problems with e.g., water leakages. They suggested a support line and someone that can come home and discuss different solutions with them.

The group discussed several ethical concerns raised by each of the three scenarios presented. During the water leakage scenario, Gunhild emphasized the importance of identifying the party responsible for fixing the leakage, exemplified by a previous dispute between the municipality and a homeowner. The group agreed that digital water meters should be made mandatory to ensure a fair use for all citizens. However, they recognized the need for clear regulations outlining ownership and servicing of the devices, as well as how data collected from them could be utilized in a transparent way by the municipality and other stakeholders. In addition, they advocated for diverse communication channels between citizens and the municipality such as email, website, mobile app and telephone to enable accessibility for all.

### D. All groups

#### 1) Securing participation

##### a) Coming up with ideas

How the groups generated and promoted ideas differed between them and we see the expert's role understanding as an important factor to explain this. The expert in group three actively invited participants to come up with ideas. In contrast, the expert in group one decided which ideas were feasible and which were not. In general, most of the participants engaged in the discussions and were able to formulate opinions on the themes brought up by the design fictions. There were two participants, however, one in group one and one in group two, who mostly listened and did not speak much.

##### b) Agreeing

The experts understanding of his / her own role in the discussions to a large degree influenced the power dynamics in the group. The expert in group three summed up the group's findings covering all contributions. This contrasted with how both Roger and Hans summed up their group's discussion relating their own understanding of the topics at hand.

##### c) Coming up with alternative visions

All three groups came up with concrete suggestions for each design fiction scenario. The solutions were modest and not as radical as we might have hoped. Participants highlighted that they needed more guidance to understand the changes implied by upgrading the water infrastructure. Further, they suggested that they should be able to choose alternative services both for monitoring water and communication between them and the city. Finally, participants highlighted that is important to be transparent who owns and services the digital water meters and how their data is used by the city and possibly other stakeholders.

## 2) *Raising ethical concerns.*

The overarching ethical concern brought up in the discussions in all three groups, was how data from the new digital water meters trigger privacy concerns. It seems that all group members, including the experts, were acutely aware of privacy regulations (i.e., GDPR) and didn't want to question these in general. When the groups discussed questions of security and sustainability, however, dilemmas pitting privacy regulations against conceived utility surfaced. The groups were willing to give consent to use data to take care of their properties and health on a case-by-case basis. Further, they considered loosening privacy concerns and lessening the need for informed consent to stop wasteful use of water in times of acute shortages.

## V. DISCUSSION

The point of using Design Fictions as method when involving citizens in the project of installing digital water meters was to 1) make digital water meters and the infrastructure they are part of visible, relevant and provoking to the participants, 2) to encourage critical reflections and discussions where all stakeholders could take part and have their voices heard, 3) to envision alternate futures by working out how current policies and regulation should be updated to accommodate "smart" use of the opportunities the digital water meters embody and of course to mitigate negative consequences and lastly 4) to shed light on how participatory design fiction could raise ethical concerns among citizens experiencing them. We will now discuss whether the participatory design fiction method worked as expected and what we learned from applying the method for these purposes?

First, we see how our application of the method made the digital water meters and the infrastructure they are part of visible, relevant, and somewhat provoking to the participants. It created a common ground for discussing the possible consequences of a not yet implemented smart city technology. The stories and materials provided seemed to both initiate and to some degree sustain discussions in all three groups. All three scenarios were taken up in discussions and when the groups had come to an end point on an issue, they came back to the task by looking at the provided materials. A possible takeaway from this is that it is important to use time on developing the scenarios beforehand, so they communicate well. We believe it is crucial for designers, wanting to use this method to heed the basics of storytelling as applied in journalism, to make the stories both relevant and provoking.

Second, while the scenarios encouraged critical reflections and discussions where most of the participants took part, they didn't provide enough support for equalizing power relations between citizens and experts in the workshop. In two of the three groups the citizens suggestions were to a large degree corrected or ignored by the expert in the group. Based on this finding, we believe the method should be updated with more rules when it comes to turn taking and more specific instructions for how the contributions should be captured and summarized for each scenario. The many breakdowns in the budding speculative discussions between the citizens could have been avoided with clearer rules of engagement.

Third, the proposed visions of alternative futures in the workshop were rather down to earth and close to what will most likely be implemented in the future. We believe this to be a direct consequence of how the experts performed their role in the workshop. All three were quick to provide facts from the project when the citizens started speculating. A possible takeaway from this is that we should have prepared the experts beforehand, to give them a better understanding of their role in the workshop. We should have asked them to play with the scenario a while longer, before providing the facts (with its many constraints), for the sake of provoking more lively discussions. One example is how they could have suggested the opportunities to regulate water consumption from installing smart water meters, that can't be realized due to privacy regulation.

Lastly, we found that participatory design fictions as applied in the smart water workshop, created a space for citizens to reflect and discuss their ethical concerns and have most likely raised their awareness of these issues further. Participatory Design (PD) has from the start taken an ethical stance, facilitating for such spaces [26], creating regular venues to discuss values [27]. Adding design fictions to the toolbox of PD gives PD practitioners more opportunities to make ethical dilemmas with future smart city technologies relevant and available to citizens. The best evidence from the workshop was how scenarios implying misuse of data from smart water meters, immediately triggered discussions of privacy concerns with the new capabilities offered by the proposed technology.

## VI. CONCLUSION AND FUTURE WORK

In this paper, we have explored participatory design fictions as a method to involve citizens in processes of digitalizing critical infrastructures. Based on a workshop to engage citizens in upgrading the water system with digital smart water meters in a mid-sized city in Norway, we find the method promising. It enabled the citizens to discuss multiple aspects of the suggested upgrade, concerning security, sustainability and privacy. We find that we need to strengthen the method further, however, by adding some more rules of engagement and by prepping participating experts beforehand. The main challenge is to move the discussions beyond the easily observable facts and political correctness and towards addressing alternative and maybe thought-provoking visions of the future.

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