Playground Oracles: Speculative Enactments for urban digital twins & participation

master's thesis

by david tiemstra
who studied
design for interaction
at
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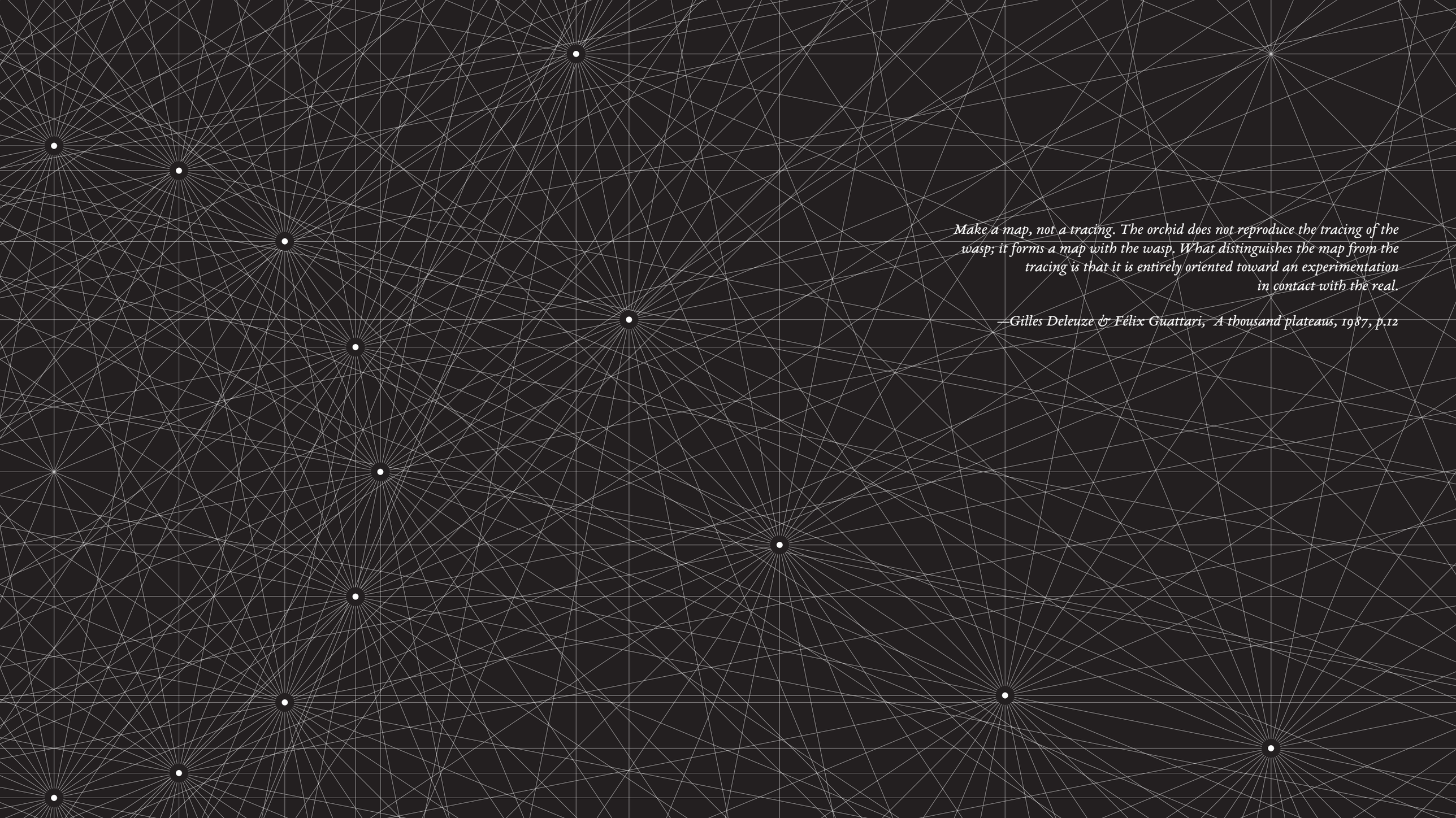
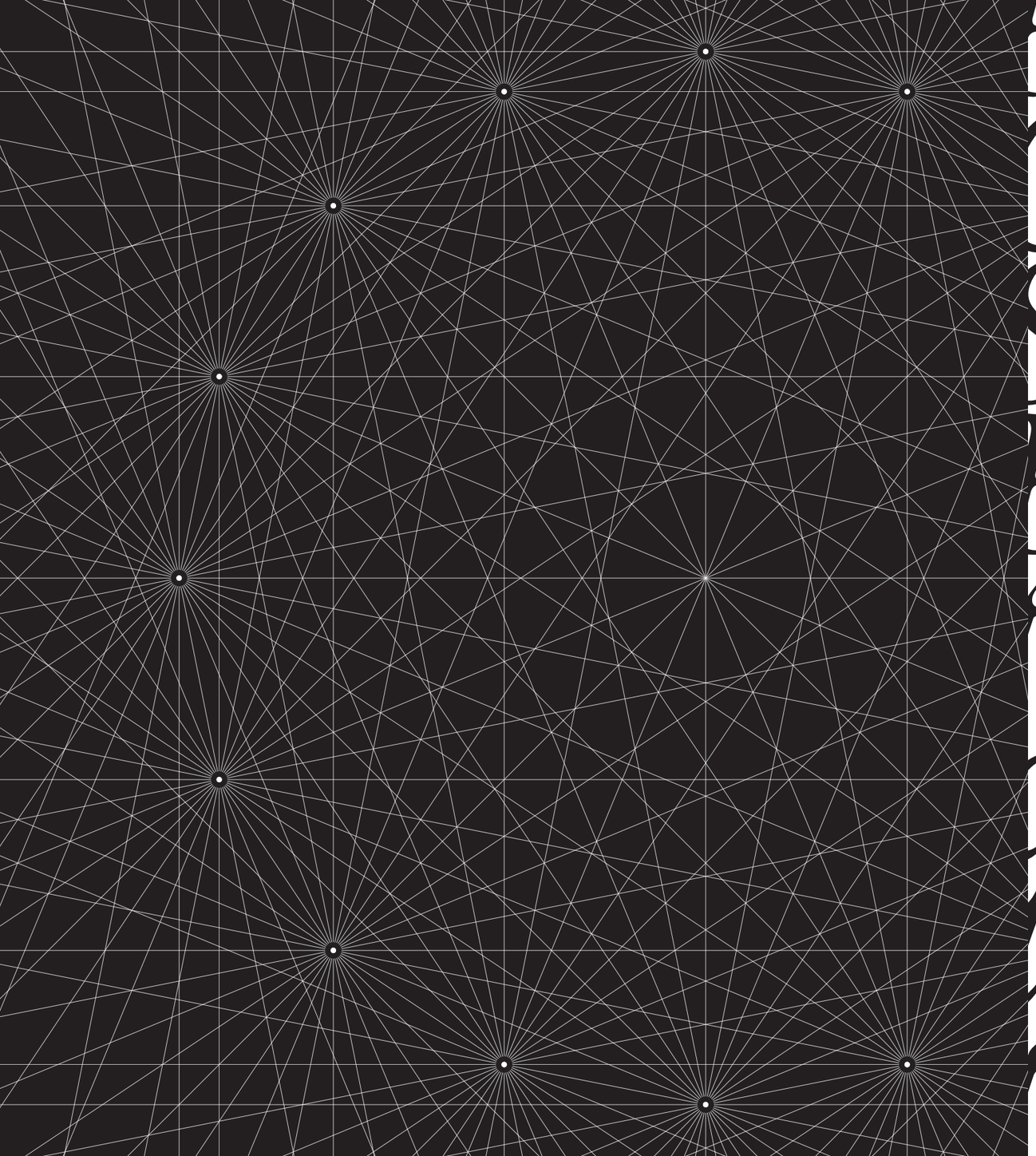


Make a map, not a tracing. The orchid does not reproduce the tracing of the wasp; it forms a map with the wasp. What distinguishes the map from the tracing is that it is entirely oriented toward an experimentation in contact with the real.

—Gilles Deleuze & Félix Guattari, A thousand plateaus, 1987, p.12



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abstract

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Cities want to give birth to their own twins, on a computer.

The urban digital twin is a digital copy of the city constructed from heaps of data rather than concrete, and it is being heralded as the driver for Smart Cities: by collecting more and more data and processing it in more and more sophisticated models we would monitor, predict and control the physical city's behaviour to engineer solutions for today's most pressing issues, from climate adaptation to crowd management and from infrastructure to governance.

This research critically examines the role urban digital twins can play in processes of public participation. While regularly mentioned in urban digital twin proposals, little research exists exploring this application, even less that takes a critical stance. One city that is looking to use urban digital twins in participation is Den Haag, which has started work on an urban digital twin called *De Digitale Spiegelstad (The Digital Mirror City*), and research has taken place primarily in the context of this city and this project.

To this end I iteratively developed visions of what a future *urban digital twin for participation* could look like. These visions challenged the mainstream or obvious narratives around urban digital twins, following the Adversarial Design philosophy of Carl DiSalvo. This led to a prototype that was used to act out a process of participation concerning the redesign of a playground with residents of the neighbourhood Moerwijk, using the research method of Speculative Enactments developed by Christ Elsden and colleagues. Enactments were followed by group interviews with participants about potential risks and benefits of urban digital twins for participation.

The thesis concludes that urban digital twins may have the potential to make public participation engaging to a wider group of citizens and could contribute to citizen trust and transparency in decision-making, but also poses the risk of steering citizens towards technocratic perspectives and leading conversations to focus on details rather than bigger issues. I provide a series of design recommendations in response to these.

Lastly I reflect on the methods and execution of the project, and the implications this may have for design researchers seeking to embark on a similar journey.

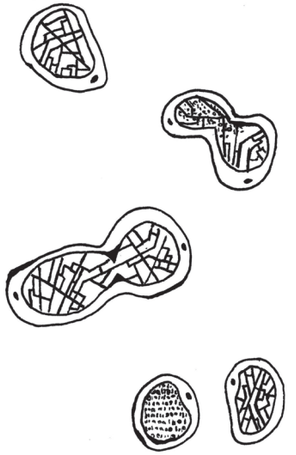


figure 1.
urban digital mitosis

glossary

Adversarial Design – a critical design philosophy developed by Carl DiSalvo building on the concept of agonism.
Agonism – a political and social theory that emphasizes importance of conflict.
charrette – a method of deliberation, through which participants from different subgroups of society reach a consensus position in a relatively short time.
correspondence participation – participation that is conducted asynchronously, generally online.
critical design – an umbrella term for forms of design that do not seek to produce marketable products but rather bring societal issues to light.
GIS – geographic information systems, digital tools used to store, visualize, analyze, and interpret geographic data.
reconfiguration – a term I use throughout the thesis to refer to forms a future system could take that differ from the mainstream vision of that system's future, loosely adapted from Adversarial Design.
speculative design – related to critical design, speculative design speculates about possible futures through design, often with the goal of inspiring the imagination.
Speculative Enactment – a research technique within speculative design that speculates about an alternative future or present by acting it out with participants. Developed by Chris Elsden and colleagues.
urban digital twin – 3D models of cities with integrated layers of data and simulation capabilities.

NOTE ON TRANSLATION

This project was conducted in the context of the Netherlands and most of the cited interviews and conversations were held in Dutch. While all Dutch phrases have been translated to English, in cases where no translation exists that accurately captures the connotations of the original, the Dutch phrase has been added between parentheses in italics, for example: loitering youth *(hangjeugd)*.

FOREWORD

What was your thesis about again? Speculative enactments... for urban digital twins... and participation... ah.

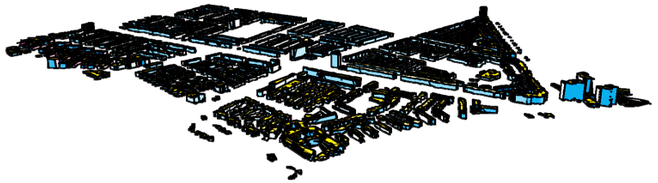
I admit I didn't pick the most accessible title for my project, but then it's not the most accessible topic. Over the past half year I've had to go through this routine of explaining what every word in that title means and how they're related so often I think I'm close to perfecting the technique, and hopefully it shows in the text. A cute detail is that I also had no clue what digital twins were when my chair brought them up during one of our first meetings as a potential topic to write a thesis about. I think I nodded and said I'd heard of it but didn't know all details. An even cuter detail I encountered early on in the project is that no one really has a good idea of what urban digital twins are. Not that it mattered, here was a buzzword being thrown around by tech guys as the next thing that's gonna save cities, ripe for critique through design speculation, something I learned about a few months earlier and thought sounded cool. Somewhere along the way I decided the scope should be public participation—another topic I had no prior knowledge or expertise on—and I was set to go.

While I may not have known what I was getting into, choosing topics I know nothing about is what I usually do, and in this case specifically the decision has proven quite fruitful. I hope you'll enjoy the journey as I brief you on all I've discovered over the past six months about these three topics: speculative enactments, urban digital twins, and public participation.

ACKNOWLEDGEMENTS

First, some thanks are in order. I'd like to thank Mandy Koenraads of the Thesis Hub The Hague South West for providing me with the connections, methods and even location I needed to complete my research. Stefan Los of the Digitale Spiegelstad for your continued interest and support of the project. Berit Piepgras of Haags Samenspel for teaching me about participation in Den Haag and for bringing me into the context. I'd also like to thank Asefeh for quite possibly saving my research and for all the enthusiasm, Achilleas Psyllidis for keeping me from going (too far) off track, and Roy Bendor for all the sources, all the guidance, for always being critical throughout the journey and for encouraging me to do the same. Lastly, I want to thank all my friends at IDE for being there and dealing with me everytime I had a meltdown over this project, and my family for being so patient and supportive (and also for proofreading hehe).

contents



First chapter; Context

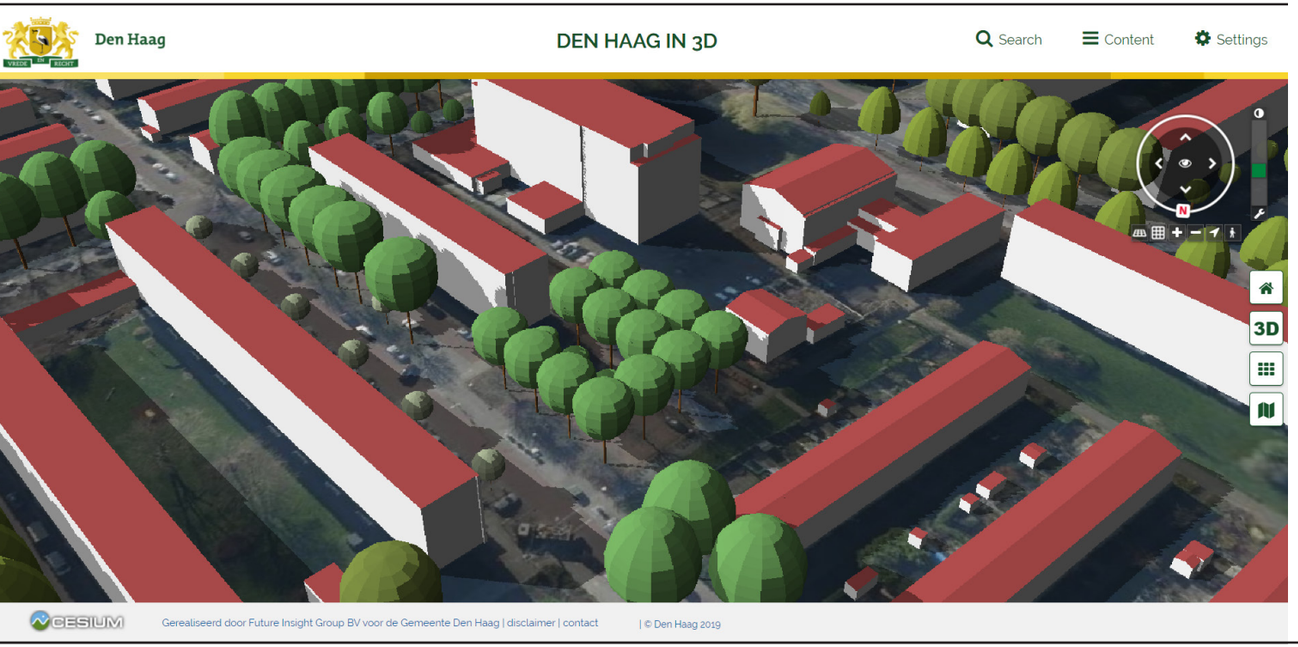
This introductory chapter lays out the context in which the project has taken place and the stakeholders that were involved.

chapter sections

section 1.1: introduction

Urban digital twins is a popular term that has proven to have at least a bit of staying power in the rapidly changing Smart City landscape. Generally speaking this refers to 3D models of cities with integrated layers of data and simulation capabilities. They are being heralded as the driver for Smart Cities by tech companies, and municipalities around the world have been quick to embrace them, one such municipality being the Dutch city of The Hague. January 1st, 2024 marks the date the Omgevingswet comes into force in the Netherlands (Ministerie van Infrastructuur en Waterstaat, 2023). Among other reforms, this increases the responsibility of municipalities to conduct public participation when proposing spatial policy. Among the many use cases being proposed for urban digital twins, in this thesis I explore the potential they have to aid in processes of public participation, studied through the lens of the nascent digital twin of The Hague.

figure 2.
De Digitale Spiegelstad
(source: nederlandin3d.nl)



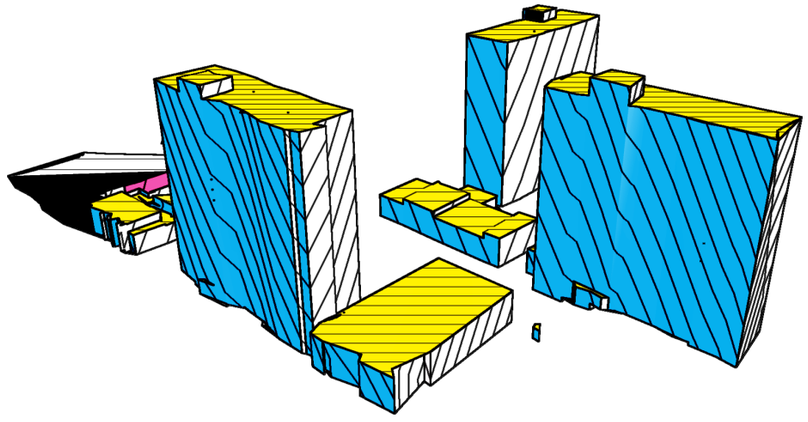
section 1.2: stakeholders

The primary audience of this study comprises current and future developers of urban digital twins considering or working on participatory applications. The study takes a citizen-centric approach as these are the people participation needs to serve, but the findings should inform the development of urban digital twins for participation. Secondly, this thesis may be of interest to design researchers for its exploration of highly embedded Speculative Enactments (Elsden et al., 2017) in a civic context.

The project takes place specifically within the context of the municipality of The Hague, which is working on its own digital twin program called the *Digitale Spiegelstad* (figure 2). While not an official client, throughout the project I have collaborated with the developers of the *Digitale Spiegelstad*, talking primarily to civil servants working in The Hague and generally situating my research there. This is not to say my research insights are not valuable to anyone outside this context, but when generalising it is important to remember they reflect the local context of The Hague and the Netherlands.

Lastly, I have conducted this project as part of the Thesis Hub The Hague Southwest project of Leiden-Delft-Erasmus, which has helped me get in contact with the municipality of The Hague and supported me in various ways with citizen research.

› end of chapter one



Second chapter; Literature

This chapter explores the current literary perspective on urban digital twins and the potential they may hold for public participation. Starting with a history and definition of urban digital twins, I develop a classification of urban digital twin functionalities. By connecting this to an existing taxonomy of public participation I map out the possible directions of urban digital twins for participation, from which I select my scope based on public participation literature. Finally I review current critiques applicable to urban digital twins for participation from literature and end by defining my research question in response to this.

chapter sections

section 2.1: digital twins & cities

SUBHEAD

The aim of this section is to reach a working definition of urban digital twin. By exploring the history, literature and current proposals of urban digital twins, I define a taxonomy of digital twin functionalities to be used for discussing their potential role in participation and for scoping the research.

To define the scope of our topic we must first define what city digital twins are. With many similar terms being used for different concepts and use cases, it can be useful to start with the origin of the term. Digital twins as a concept come from engineering, “digital twin” being a relatively new term for a kind of technology that has been in use for decades. Grieves and Vickers (2017), who coined the term in 2011, laid out the definition of a digital twin: a virtual model that “describes a potential or actual physical manufactured product from the micro atomic level to the macro geometrical level” (p.94) that is updated with data measured from the “physical twin” throughout its lifespan. They further suggest that its value is that, when you want to perform a task with or on a product of which you have a digital twin, you have the ability to substitute resources of information for resources wasted on attempting a physical implementation, since in repetitive or complex tasks, information tends to be cheaper than those wasted resources. To summarise, what distinguishes the original digital twin from any other model is its dedication to extremely precise digital representation of a physical system or object, and its purpose of testing for cost reduction using temporal simulations.

This concept has since been applied to a variety of sectors, among which building information modelling (BIM), the digital representation of buildings. In more recent years, BIM has begun to fuse with geographic information systems (GIS), to provide digital models on a more regional level (De Laat & Van Berlo, 2011), urban digital twins, then, have arisen from this fusion (Cureton & Dunn, 2020). While a realistic model of the physical state of a building is still somewhat conceivable, it is a big leap in size and complexity from a building to a city, and it is generally accepted in literature that a realistic modelling of the physical, social and other processes that inform the development of a city is far out of reach (Batty, 2018; Nochta et al., 2021; Korenhof et al., 2021). Thus, a non-obvious choice must be made of what data and processes to include, and in this

translation the definitions of what an urban digital twin is and what it should be used for have broadened and become tangled as an increasing number of projects using the label have sprung up.

Consequently, there is no scientific consensus on the definition or even the term itself, with “urban digital twin” (Dembski et al., 2020), “digital twin city” (Deng et al., 2021), “city-scale digital twin” (Nochta et al., 2021) and other terms being used more or less interchangeably. Several literature reviews have attempted to reach a definition of urban digital twins either by their necessary components or their use cases. For example, Deng et al. (2021) suggest they are models that combine technologies of surveying and mapping, BIM, IoT, 5G, collaborative computing, blockchain and simulation, while Shahat et al. (2021) list as general themes data management, visualisation, situational awareness, planning and prediction, integration and collaboration. The most encompassing definition is given by Ketzler et al. (2020), who identify most urban digital twin projects as consisting of three layers:
The data layer, also called the city information model (CIM). This consists of static data such as maps, blueprints of buildings and infrastructure information, as well as dynamic, real-time sensor data.
A generic platform to connect or develop various applications and analytical tools, including its capacity for simulation (this creates the added value of the digital twin)
The interface. Visualisation, dissemination and/or user interaction, these are often enabled through game engines and web applications

This definition still offers little indication to the limits of what urban digital twins can or can’t be since the second layer is left open. Ketzler et al. recognise that much writing on urban digital twins consists of grey literature and projects do not define themselves by a scientific consensus but in reference to previous projects. Therefore, rather than pursuing a rigid definition of what urban digital twins can be, it may be more valuable to investigate what they are likely to be by looking at prominent examples being referred to as urban digital twins.

One of the first comprehensive urban digital twin proposals was Virtual Singapore, first proposed in 2014 (National Research Foundation Singapore, 2014). This contained many of the concepts and use cases that later projects would embrace and has been cited as an example in multiple case studies (White et al., 2021; Schrotter & Hürzeler, 2020). The terminology they use is somewhat vague, listing capabilities and use cases with no clear distinction between these categories. This is a problem shared with more urban digital twin initiatives, as many of these are projects that promise to integrate a broad range of technologies to potentially serve a broad range of ends. As this research concerns the use case of public participation I have tried to isolate the functionalities

and grouped them into two broad categories: (1) urban digital twins as a *source of knowledge* and (2) urban digital twins as a *platform* for communicating with other actors such as other municipal departments, companies and citizens. Table 1 explains the different functionalities. For each functionality I cite urban digital twin initiatives in the Netherlands that are proposing or applying them, these are taken from the state-of-the-art review of urban digital twin initiatives in the Netherlands conducted by Ávila Eça de Matos et al. (2022), the numbers by which they are cited correspond to the table in appendix A.

These functions also overlap and feed into each other: the *knowledge* functions of the urban digital twin are used in the *platform* functions. The urban digital twin functionalities are mapped out in figure 4.

figure 3. digital twin of alkmaar showing current and historical traffic data (source: digitale-tweeling-alkmaar.azurewebsites.net/digitale_tweeling)

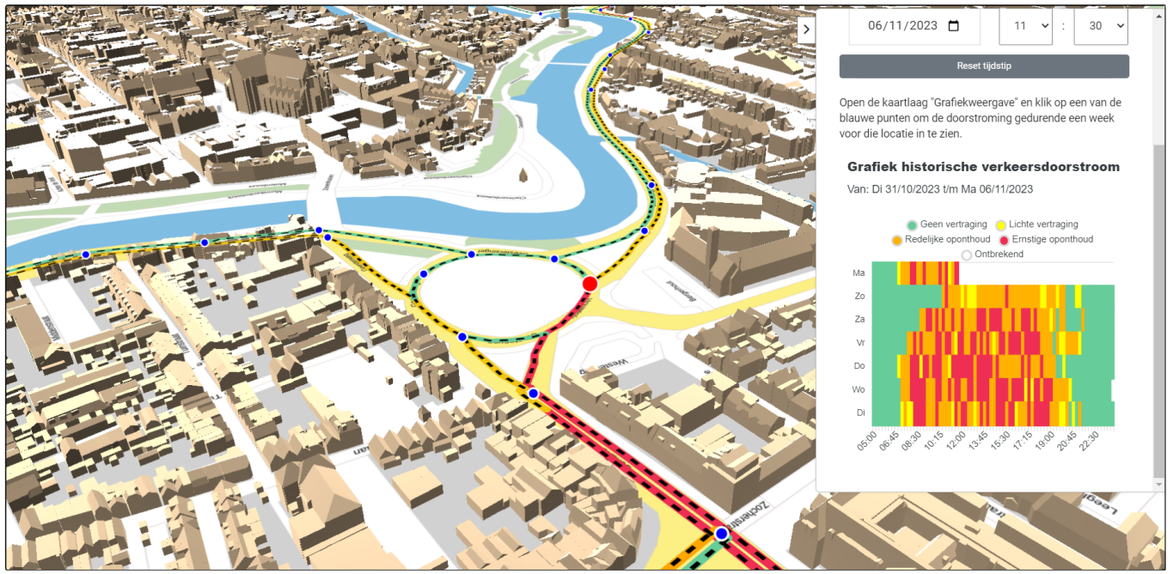


figure 4. (opposite page, above) urban digital twin functionalities

table 1. (opposite page, below) commonly proposed urban digital twin functionalities, created by the author using examples reported by Ávila Eça de Matos et al. (2022)

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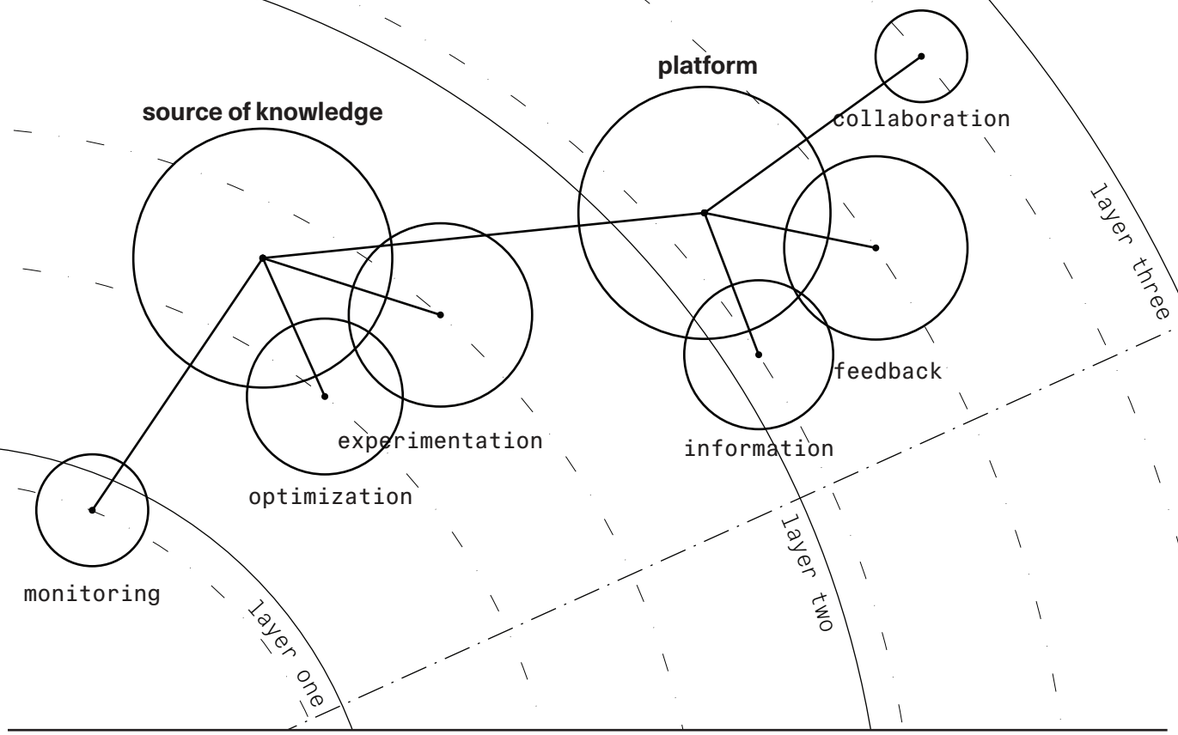


function	description	examples
monitoring	The digital twin is used to view static and dynamic data collected from the city in one place, this could be the dimensions of a tree (static) or the current business of a street (dynamic). This is the lowest level of digital twins as a *source of knowledge*.	
optimisation	The aggregate data in the model is used to calculate more optimal implementations of systems, such as using sun and weather data as well as building geometry and energy consumption over time to determine the optimal placement of solar panels.	
experimentation	The digital twin serves as a testbed for future plans or scenarios to see how they would look and predict how they may unfold. This could be the impact of placing a new building on air quality, or using historic mobility data combined with infrastructure data to predict crowd dispersal in case of an organised event. There exists overlap between *experimentation* and *optimisation*.	
inform	Actors can view data that has been made available to them in the digital twin by the developers, such as static and dynamic data about the city as it is or visualisations of buildings that are still under construction and other plans by the municipality.	
feedback	Actors respond to the data presented in the digital twin, such as voting on a preferred design between multiple proposals, or leaving comments on a piece of street furniture they would like to see revised.	
collaborate	Actors can add or edit data in the digital twin. This opens up a broad range of applications: the digital twin can be used as a platform for integrated data exchange between public and private sector organisations, citizens could submit a new design for a park or work on it collaboratively, or planning agencies can visualise their planned or ongoing projects and harmonise them.	

ch2.literature sc2.digital_twins&participation

section 2.2: digital twins & participation

Having defined what urban digital twins can be in the previous section, in this section I explore how they can fit into a municipality initiated process of participation. I do this by first giving a definition of public definition, then categorising the different forms it can take and questioning which are most preferable. Using this classification I show which functionalities of urban digital twins can be used for which forms of participation, finally scoping my research to include the overlap between urban digital twins' functionalities and the forms of participation deemed most interesting.

PUBLIC PARTICIPATION

Public participation can be defined as the mechanisms by which stakeholders are involved in a decision-making process. When participation is absent, projects are based on technocratic perspectives (Birhane, 2022). This research focuses more specifically on processes that involve citizens in urban planning. Innes and Booher (2004) identify five goals shared by most participatory processes:

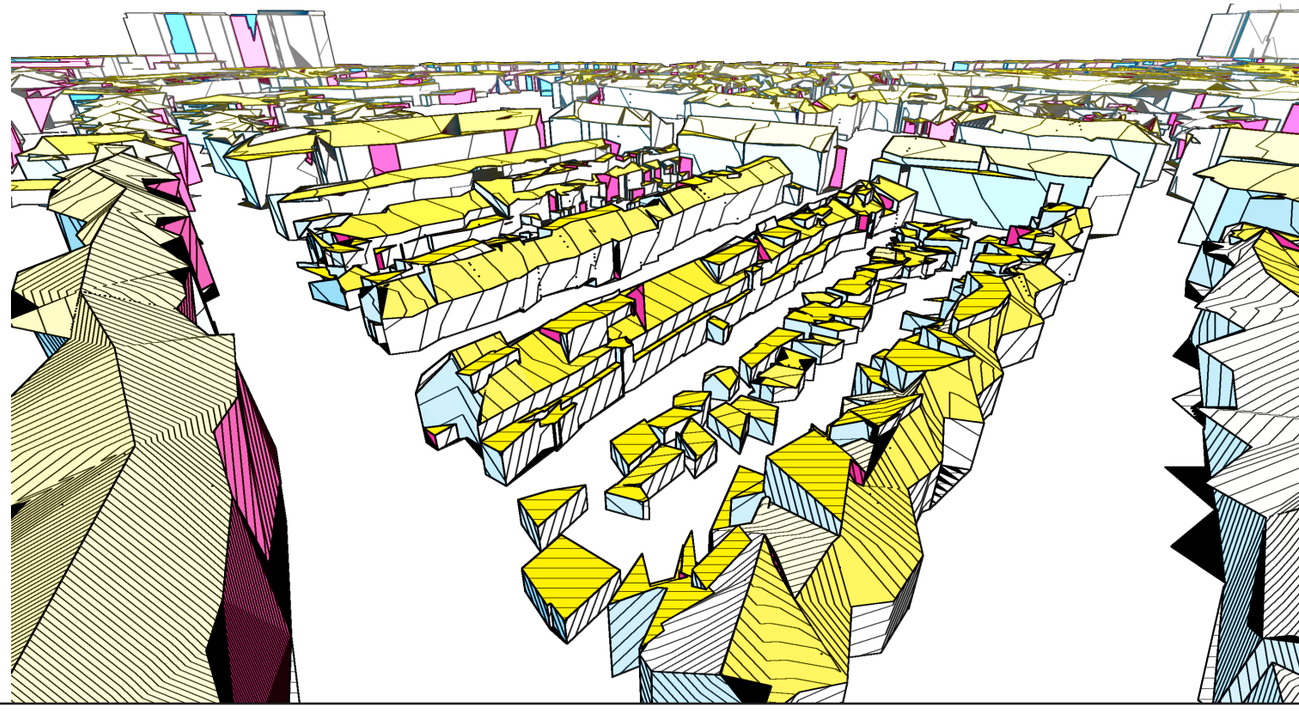
1. Discovering the preferences of the public.
2. Incorporating citizens' local knowledge.
3. Advancing fairness and justice by discovering the needs of groups that are not recognized through normal information sources.
4. Granting legitimacy to public decisions by showing a support base.
5. Meeting legal requirements for participation.

Later on, we can draw upon these goals to assess the effectiveness of participatory applications.

CATEGORISING PUBLIC PARTICIPATION

Participation can take multiple forms, and to understand where digital twins can fit into these processes I will draw upon a typology of participation. The first and most commonly cited classification is Arnstein's (1969) ladder of participation. Arnstein saw public participation as citizen power in public decisions, and classified processes by the amount of power they extended to the public, defining eight levels (in ascending order): manipulation, therapy, informing, consultation, placation, partnerships, delegated power, and citizen control.

As it dates back to the late 60s, it has been argued that Arnstein's ladder does not accommodate modern forms of participation since it does not fully account for the ways participation works in today's neoliberal, entrepreneurial cities (Cardullo & Kitchin, 2019), therefore Cardullo and Kitchin (2019) have developed an expanded classification called the *scaffold of smart participation* (figure 5). This framework



ch2.literature sc2.digital_twins&participation

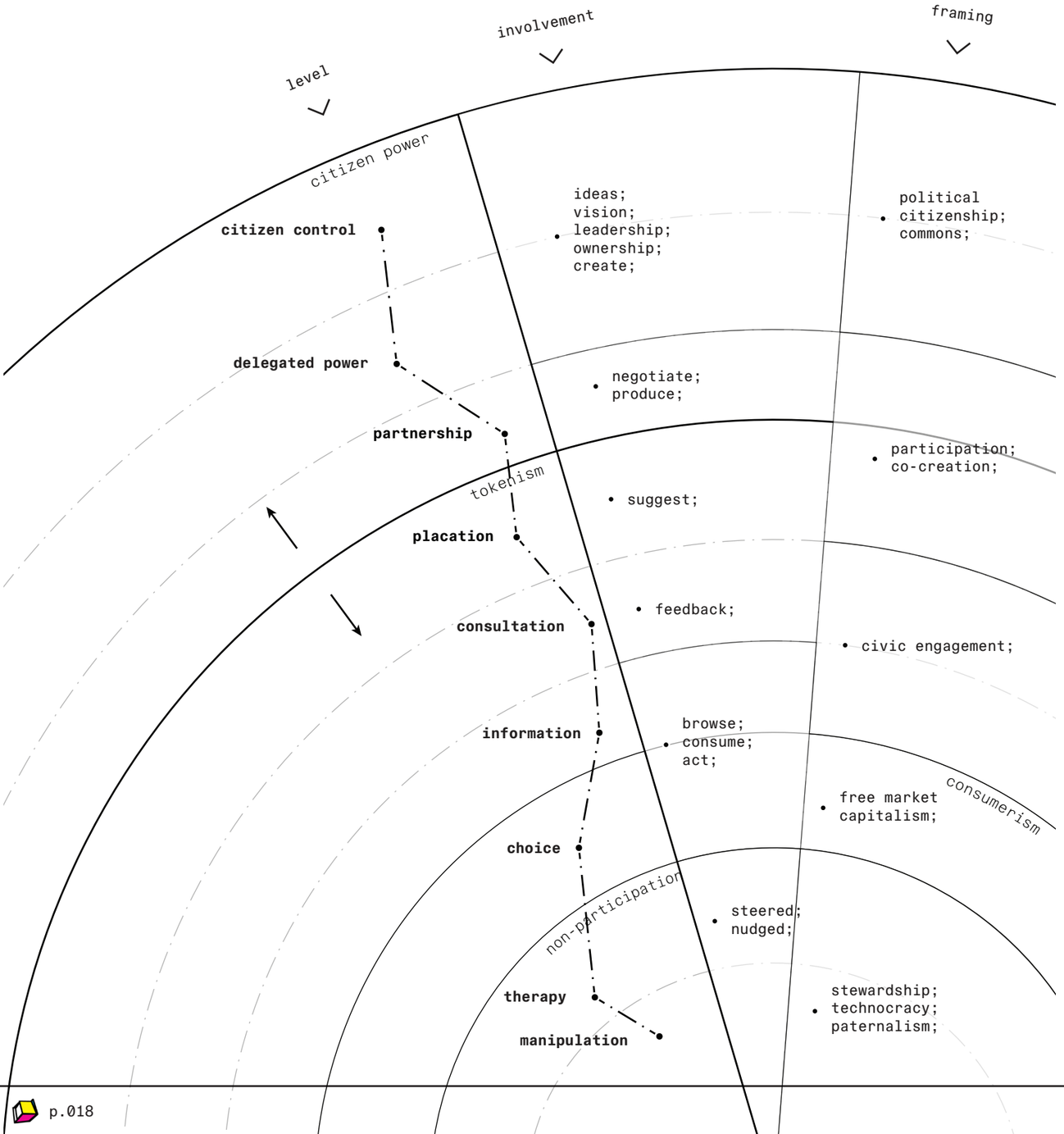


figure 5. (opposite page) scaffold of smart citizen participation, adapted from Cardullo & Kitchin (2019)

GOALS OF PARTICIPATION

expands Arnstein's original ladder both vertically with the addition of the *consumerism* form of participation, and horizontally with four columns that contextualise the levels by indicating the kind of role it has reserved for the citizen and the form of their involvement, as well as the political framing that informs processes at that level, and their modality (top-down or bottom-up).

The four forms of participation, as explained by Cardullo & Kitchin (2019), express themselves in smart city participation in the following ways:
Non-participation: citizens are steered towards certain behaviours, they are used as data points, having their data collected through various sensors for use in technocratic decision-making they themselves have no direct influence on.

- Consumerism: citizens are offered a choice of smart products/ services to use. While these may radically shape the functioning of the city, the citizen has little influence on the way in which they do.
- Tokenism: this is where most activities defined as top-down participation take place. At the lowest level, information, citizens receive (access to) data on the processes taking place in the city without being given power to influence it. Beyond that, in consultation, citizens are asked for feedback on the developer's plans, and finally, in placation, citizens can suggest alternatives or make their own proposals. While in this form citizens can challenge the assertions of the experts, they are not given the power to make the decision.
- Citizen Power: in this form citizens have genuine decision-making power, with levels being distinguished by them having partial (partnership), dominant (delegated power) or full (citizen control) control of the decision-making.

So what forms and levels of participation should we aim for, and in what situation? Disregarding *non-participation* and *consumerism* as pitfalls for participation to fall into when done wrong, rather than substantive forms of it leaves *tokenism* and *citizen power*. Arnstein (1969) argued that in tokenism there is no guarantee that the status quo will be changed, since in the end citizens are only given the right to voice their opinion but no power to enforce it, revealing the need for citizen power. Furthermore, Cardullo and Kitchin (2019, p. 8) point to "a bias towards the views of well-educated, technologically-literate participants in the digital public sphere," as well as issues with long-term crowd retention and validity, reliability and trustworthiness of the data generated in participatory processes classified as *consultation* and *placation*. Cooke and Kothari (2001) argued that in some cases, participatory processes can lead to reinforcing the interest of those in power and force out other decision-making processes that may be more suited. While some planners seek to approach citizen control, most simply inform the public

SCOPING DIGITAL TWINS & PARTICIPATION

and seek consultation as a compulsory task (Gordon et al., 2011; Innes & Booher, 2004). Gordon et al. (2011) argue against Arnstein's unconditional appraisal of citizen control as the best form of democracy: while public agencies can make decisions that are bad for the citizens affected and alienate residents by leaving them out of the process, uninformed or emboldened community groups can be just as detrimental or disruptive to the decision-making process. Instead they emphasise the importance of the design of the specific participatory process. While their concerns resonate, I do not view this as a refutation or an argument to not strive for citizen control, but rather a challenge for the designers of the participatory process to facilitate healthy decision making with high citizen power. Here the use of urban digital twins may be able to play a role.

By connecting the urban digital twin functionalities from figure 4 to Cardullo & Kitchin's (2019) scaffold, we can get an idea of the ways in which digital twins can fit into processes of participation (figure 6, below). The three presently proposed platform functionalities of inform, feedback and collaborate can be mapped to the three levels of Tokenist participation, information, consultation and placation, respectively, with any of the three source-of-knowledge functionalities potentially supporting the participatory process. In addition, if more decision-making power is given to citizens the digital twin functionality of collaborate also extends upwards to include the partnership level of participation, encapsulating the border region between top-down and bottom-up participation which Cardullo and Kitchin (2019) assign the framings "participation" and "co-creation". If they can deliver on their promise of providing an intuitive understanding of complex data and analyses, urban digital twins can address the tension identified by Gordon et al. (2011) between uninformed citizens and detached planners. In other words, if they can employ their source of knowledge functionality in support of their collaboration functionality they may be able to facilitate participation that is justifiably more empowering to citizens. The exploration of this dynamic defines the scope of my research (also indicated in figure 6 in magenta):

I want to explore how all of the urban digital twin's source of knowledge functionalities–monitoring, optimisation and experimentation–can together be leveraged through the digital twin's collaboration functionality, to facilitate a move from placation to partnership within a participatory process.

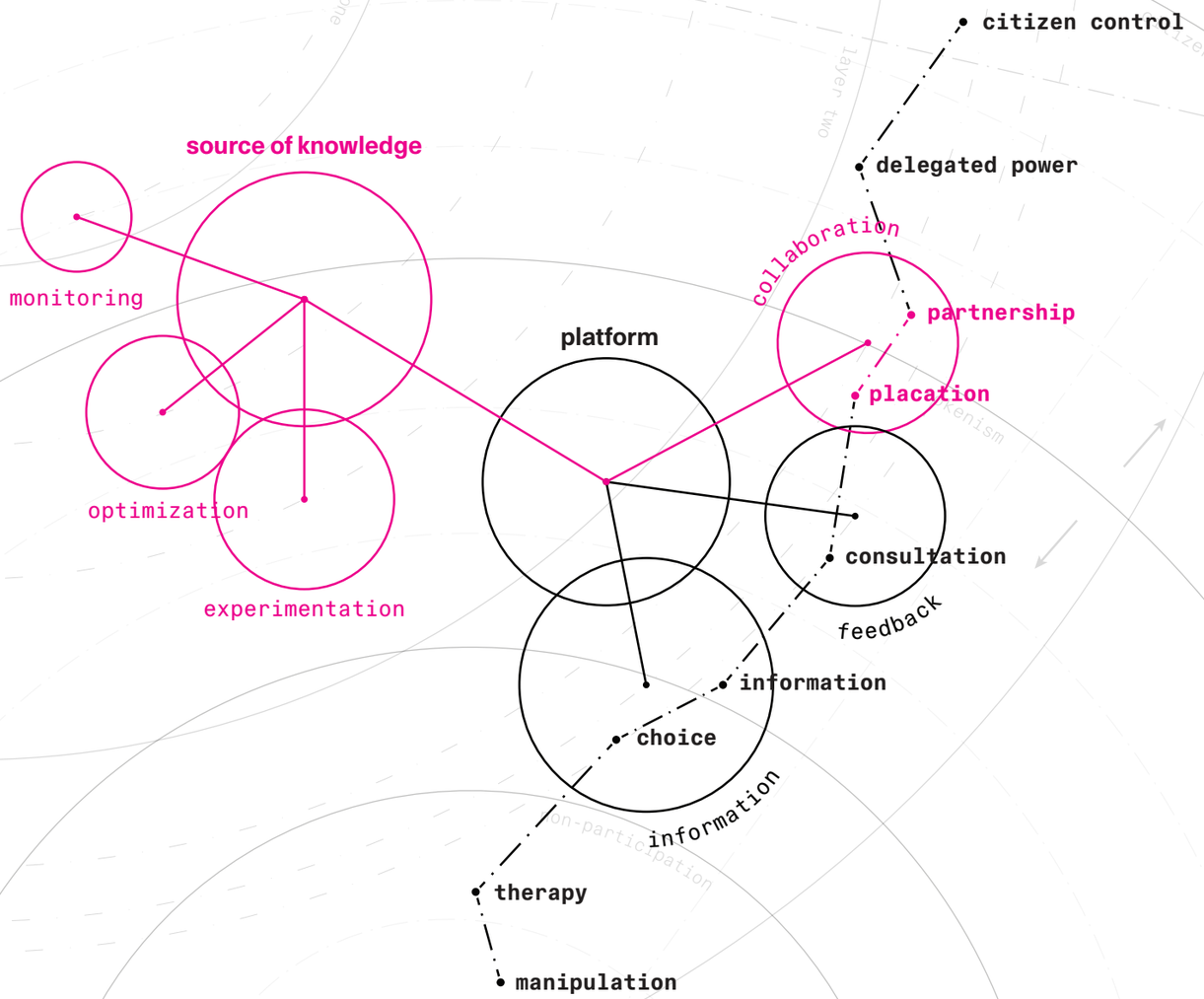
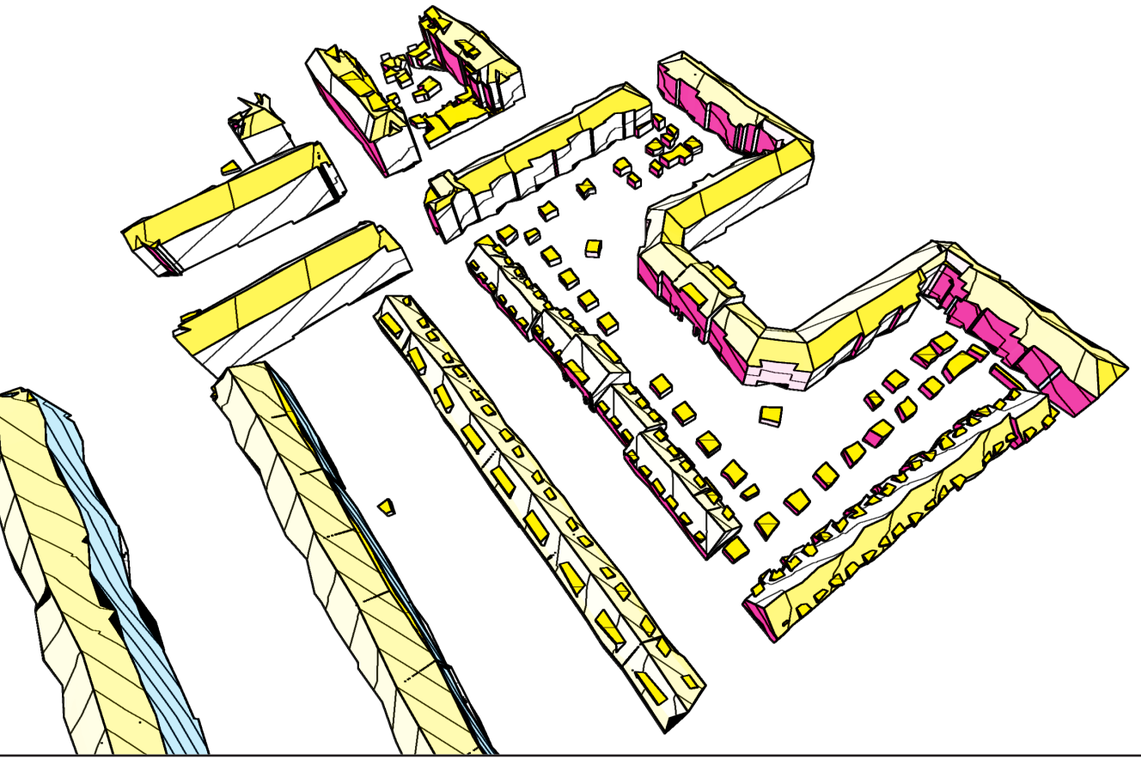


figure 6.
urban digital twin functionalities as modes of participation, research focus in magenta

section 2.3: critique of urban digital twins for participation

As no research has been done to assess the potential of urban digital twins as a tool for *co-creative* public participation, the following section attempts to establish a preliminary overview of potential risks and benefits based on available literature, this includes (1) case studies concerning digital twins used in some other form of citizen *consultation*, (2) critique from general urban digital twin literature that is applicable to the context of participation and critique from literature on adjacent forms of public participation that is applicable to the context of urban digital twins.



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ONE: RELATED CASE STUDIES

One case study in Germany engaged citizens in physical sessions for collaborative planning supported by various urban digital twin applications presented in VR for visualisation and simulation (*experimentation*), and found that participants found the process more interesting and entertaining than traditional participatory processes but did not further investigate the results (Dembski et al., 2020). A digital twin of Dublin afforded citizens to walk around a digital space featuring proposed buildings and green spaces and place comments and votes on interventions (*feedback, consultation*), the study concluded this could lead to "a lot of valuable feedback" (White et al., 2021, p. 10). A third study in Zürich provided citizens with navigation and unspecified design tools to create and submit designs for the city, it claimed anecdotally that it was found easy and intuitive to use to test persons "without a planning background and without special computer affinity" and opened the door to low-threshold, convenient and time independent participation (Schrotter & Hürzeler, 2020, p. 110). In summary, none of these case studies critically questioned the use of urban digital twins for participation. In Rotterdam, a pilot was conducted using the digital twin of Rotterdam (de Digitale Stad) in the participatory redesign of a public square, where citizens could create and view designs through a web page (*placation*). In a study of the pilot, limited participation and empowerment were found as a result of power imbalance and a digital divide, as well as a need for more inclusivity and transparency in decision-making (De Jaeger, 2023). This need is further corroborated by a survey conducted in The Hague about citizen's motivations to participate using urban digital twins, which identified exertion of influence on the decision-making process as the most important motivation across groups (Jansma, 2022). While the unquestioning optimism of international projects is met with more scepticism domestically, these studies only addressed high-level questions which offer limited support in the design of an urban digital twin application for co-creative public participation, pointing towards a need for more specific research.

TWO: GENERALISED LITERATURE

I have identified four core criticisms that can be related to urban digital twins for participation, each of which I review in detail.

a. Digital twins are non-neutral translations of reality and using them in decision making can enforce in reality the biases that inform the model.
b. Urban digital twins are often implemented in a single centralised tech push that ignores the requirements of local contexts.
c. Traditional modalities of participation tend to either risk misrepresenting participants' opinions, or creating power imbalances between participants and developers.
d. Digital participatory processes typically engage only the same, small demographic.

A. NON-NEUTRAL TRANSLATION

A much cited early critique of urban digital twins is Michael Batty's (2018) editorial in which he makes the less than groundbreaking observation that digital twins are models and that models are by nature simplifications of reality–digital twins of cities more so than most. Despite his admission that this is what makes the model useful to begin with, this argument has remained at the heart of much urban digital twin criticism (cf. Cureton & Dunn, 2020; Korenhof et al., 2021; Nochta et al., 2020). While its value as a conceptual critique is questionable, it does point to a misleading naming convention and marketing strategy, as the digital twin does suggest a 1:1 correspondence to the physical counterpart, and this has implications for potential use in processes of participation, when participants are presented with a model they are meant to believe is a perfect mirror of reality while in truth, less than non-perfect, the digital twins are approximations of reality developed by humans based on data and therefore reflect both the biases of the data and the human developers through the design decisions they make, such as whether to rely on machine learning or traditional predictive models and how inaccuracies in the data are communicated. This makes urban digital twins a *non-neutral* translation of reality (Korenhof et al., 2021), and these biases can then be reflected in the decisions made using the model, potentially reinforcing them further (Batty, 2019). This risk, in a similar form, has already been observed as far back as the 90s, when use of geo-information systems (GIS) was becoming more common in processes of participation, and the high-fidelity visualisations they produced provided proposals with a level of persuasiveness that made it difficult for citizens to contest them (Obermeyer, 1998), leading to accusations of being positivist and nondemocratic (Pickles, 1995). As they are presented now, urban digital twins run the risk of falling into the same pitfalls.

ch2.literature sc3.critique_of_urban_digital_twins_for_participation

B. LOCAL CONTEXTS

Nochta et al. (2020) also identify the need for urban digital twin applications to develop organically in response to needs as they arise, adapted to the local context, rather than in a single centralised tech push that tries to combine every detail about everything. As different situations ask for different approaches, a centralised system would either grow unreasonably bloated and expensive as it tries to accommodate challenges specific to context A in context B and vice versa, or it would have to exclude one context's challenges altogether. In the case of participation, this could for example manifest as participants being bombarded with information that is unrelated to their daily challenges.

C. CHALLENGES OF MODALITY

The practical process through which participation with an urban digital twin takes place can take on a form that is more similar to correspondence participation (asynchronous communication), whereby participants provide input online, in their own time, or to the charrette or workshop, where citizens and developers come together physically to discuss or design a proposal. Both come with their own risks: with correspondence participation, while able to engage large groups, this provides no direct dialogue between citizens and developers or each other, meaning there is no guarantee the participant's input represents their own, informed conclusion (Gordon et al., 2014). The charrette, on the other hand, can be inconvenient and only meet a small attendance, in addition to being plagued by power imbalance between participants and developers that have both more knowledge and more control of the situation (Gordon & Manosevitch, 2010). Applications of urban digital twins for participation will have to define their modality and accommodate the corresponding challenges.

D. THE USUAL SUSPECTS

Digital participatory processes on the whole, particularly within smart city narratives, also face the issue of only reaching the 'usual suspects', often white, middle-class men (Touchton et al., 2019) and people from well educated, technology savvy groups (Johnson & Robinson, 2014). Participation using urban digital twins runs the risk of falling victim to this bias as well.

ch2.literature sc4.research_question

section 2.4: research question

The objective of this thesis is to examine the ways in which urban digital twins may be used in public participation. This chapter explored the extant literature on the topic and found that, while work in adjacent fields gives an idea of the kinds challenges that may be encountered, there is no research that specifically assesses the potential of urban digital twins as a tool for co-creative public participation, likely owing to the nascency of the field and the primary investment from tech. Therefore, this research serves as an initial exploration of urban digital twins for participation, and its purpose becomes to provide a broad basis for developers and further research to build upon.

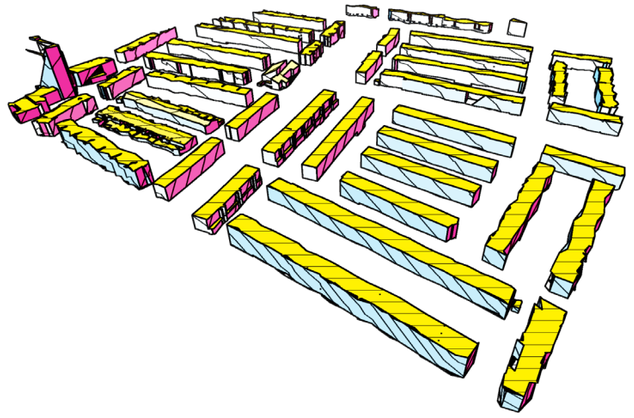
As a starting point I wish to take the citizens' perspective which has until now been painfully absent from narratives about urban digital twins regardless of their application. This is doubly important in the context of participation which seeks precisely to engage with citizens. Therefore my first research question is:

RQ1. What do citizens think about using urban digital twins in public participation?

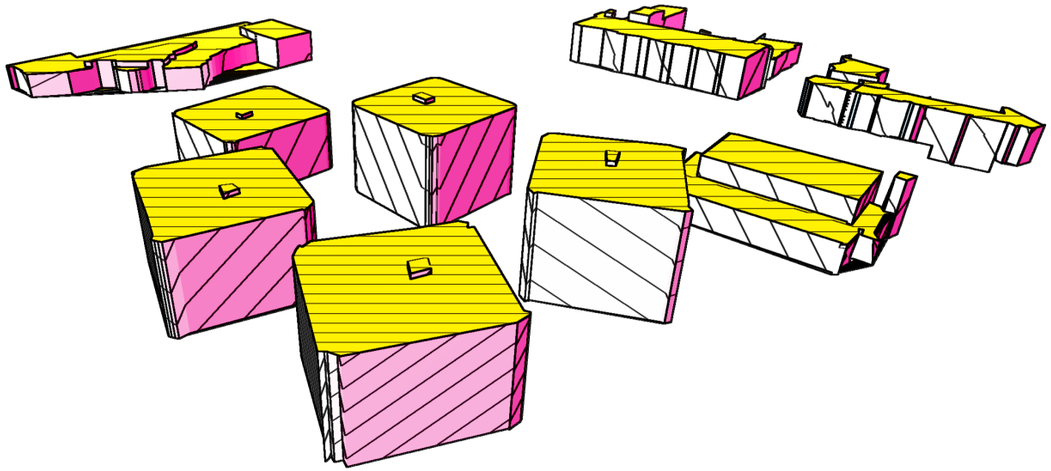
From there, I also aim to provide an overview of challenges to be encountered, in order to make the research conclusions applicable in practice by municipalities and developers. I have formulated this as the following research question:

RQ2. What are the potential risks and benefits of using urban digital twins in public participation?

Together, the answers to research questions provide a first framework for further research and development of urban digital twins for participation.



> This chapter reviewed the existing literature on (urban) digital twins and public participation. This was used to establish a working definition of urban digital twins, define a scope for the thesis as it goes forward, identify current criticisms related to digital twins for participation to engage with in the discussion, and define a research question to answer.



Third chapter; Methodology

This chapter lays out in detail the guiding method and design philosophy that shaped my research: Speculative Enactments (Elsden et al., 2017) and Adversarial Design (DiSalvo, 2012), respectively.

In short, Speculative Enactments is a method for doing Speculative Design Research in which participants act out a future. I use this method to give shape to an enactment of urban digital twins for participation that I will act out with citizens to materialise the future technology as the basis for a group interview. Adversarial design is a design philosophy emphasising the value of conflict which provides a series of tactics to elicit discourse about politically contentious technology, which is why I use it to inform the design of my enactments.

The chapter ends by exploring how the two methods may affect each other when used in conjunction, and how I intend to exploit their synergy.

chapter sections

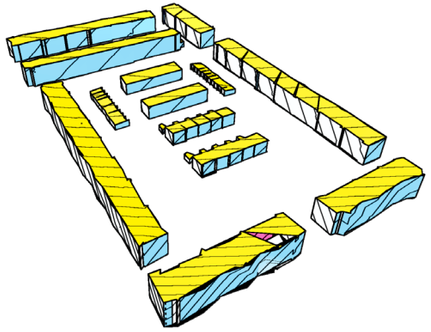
section 3.1: speculative enactments

Speculative Enactments (Elsden et al., 2017) is a method for speculative design research where participants are invited to act out a speculative scenario in a social setting, and through acting in it, shape the scenario and provide insight into the future discussed. What sets Speculative Enactments apart from similar methods is the emphasis on social interaction and consequentiality. Letting participants interact with each other in a social setting creates the conditions for values and experiences to emerge which would remain hidden in a one-on-one setting or when participants can only observe the speculative outcome. This is especially relevant in the context of citizen participation, due to the importance of power dynamics and group decision-making. Consequentiality means that the enactment is in some way of consequence to the participant: participants are forced to evaluate their actions from their real perspective, since they no longer have the privilege of slipping into the role of passive observer or to act out a hypothetical character. This helps overcome a common issue in speculative design research that Candy and Dunagan (2017) describe as the experiential gulf, the gap between the participant and the future presented to them, as well as giving the participant a strong sense of personal and collective relevance.

Consequentiality is created firstly by demanding social performance from the participants. By putting them in an environment with real people who can judge them for their behaviour the safety of the research setting is suspended. Implementing this in the enactment requires creating materials that demand social performance from the participant, meaning they cannot simply remain passive or apathetic without falling under scrutiny. I add another dimension of consequentiality by embedding my enactments in the context of a real planned spatial development project, which provides a completely real set of circumstances within which the enactment takes place. Another benefit of a consequential enactment is that it asks the participant to suspend their disbelief as little as possible, and can thereby engage people who may be less comfortable entertaining future scenarios. This serves my process well, as I work with a focus group of citizens who may approach the enactment with very different frames of reference. By providing a seemingly realistic, consequential enactment, I can get these different stakeholders to engage fully in the same scenario.

ch3.methodology sc1.speculative_enactments

While Speculative Enactments provides a useful framework for Speculative Design Research, in their own applications of the method, Elsden et al. focus on revealing experiences about future worlds and triggering the participants' imagination, while my focus is less imaginative and more reflective: I want my enactments to make the topic of urban digital twins for participation concrete for discussions, and to generate discourse. Additionally, they provide little support in designing the enactment itself. Here I draw upon the Adversarial Design of DiSalvo (2012).



section 3.2: adversarial design: reconfiguring the remainder

Adversarial Design is defined by DiSalvo (2012) as "design that does the work of agonism". Agonism, as illustrated by Mouffe (1999), is a political theory that emphasises the value and necessity of conflict between adversaries, parties holding opposing views that do not strive towards reaching a consensus, but instead struggle to defend their ideas while respecting the other's right to defend theirs. It is in this struggle that democracy is conducted. Design that does the work of agonism then creates the setting for agonistic conflict to occur. One reason this is valuable is that it provides a way for the designer to take on a less central role in the interaction than when leading the conversation, instead, particularly when applied to Speculative Enactments, their role becomes that of a facilitator of agonistic conflict between participants, encouraging them to challenge each other and deriving insights from the arguments that arise in this conflict.

DiSalvo defines three tactics for doing Adversarial Design, one of which he names reconfiguring the remainder (RtR). RtR is “an agonistic tactic of including what is commonly excluded, giving it privilege, and making it the dominant character of the designed thing.” (DiSalvo, 2012, p.64), this works by looking at the standard configuration of components and concepts in a system and recombining them (reconfiguration) in an unexpected way to subvert expectations. By emphasising what is commonly left out of the configuration (the remainder) it questions why it has been left out and what would happen if it were included, creating a basis for discussion.

I can apply RtR to the design of my speculative urban digital twin application by critically observing the standard configuration, what someone would normally expect it to look like, and reconfiguring it to subvert their expectations and open discourse about how it could or should be given form. This presents an interesting design challenge: while the technological concepts the application may combine are known–3D geometry, IoT sensor data, user inputs–their expected configurations are not. There exist some pilots I can draw upon (Dembski, 2020), but there is not yet a defined standard for urban digital twins for participation, so I will have to define this through interviews. This situation lends itself to a highly iterative Research through Design approach: by starting with a generic lo-fi prototype and using it as a conversation starter with interviewees, or in small tests with participants, I can gradually flesh out what people expect an urban digital twin for participation to be and what qualities might subvert those expectations, while simultaneously adding depth and diversity to the prototype.

Adversarial Design thus provides a framework to design the scenario and materials of the enactment, in the form of iterative RtR, as well as a guiding principle to conduct the following group interview by facilitating agonistic discussion.

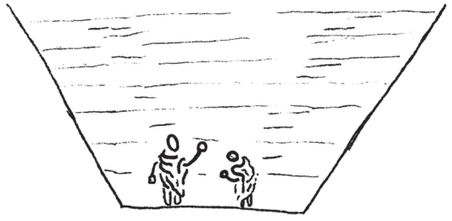


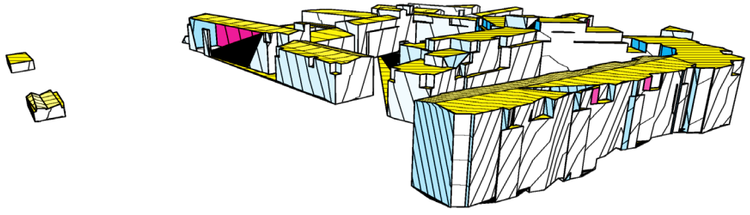
figure 7.
agon derives from ancient Greece, where it was often used to refer to the fight or debate between the protagonist and antagonist of a tragedy

section 3.3: agonistic enactments

As explained in the previous section, Adversarial Design guides the creation of a provocative future vision while Speculative Enactments explains how to use the vision in an enactment. Adversarial Design and particularly RtR, as presented by DiSalvo (2012), focus more on traditional speculative design processes that end at the production of an artefact. This artefact should then lead to agonistic discourse, as it is observed and contemplated by an audience in a gallery setting or through publication. I would argue the designer thus hands the work of agonism off to the audience: how the design affects the real world depends on the audience’s willingness to engage in the discourse and apply what it teaches them. By applying the design in embedded Speculative Enactments, I want to push DiSalvo’s approach in a different direction, one where the designer takes the design to the audience that it immediately concerns and records and analyses where the discourse leads them as a form of social research.

Speculative Enactments emphasises the power of the participants to collectively shape the future they are acting out through their actions, this can be viewed as a democratic act of futuring. Here, Mouffe’s agonism suggests a path to go beyond DiSalvo’s “hand-off”: Mouffe (1999) defines agonism in opposition to the deliberative democracy advocated by Jürgen Habermas (1992) and John Rawls (1971), that see a rational consensus as the goal of democracy. Mouffe argues that a true rational consensus is impossible and that the proclamation of one inevitably leads to the exclusion of voices. She instead espouses a “conflictual consensus” (Miessen, 2012) which is distinguished through contestability, recognising the potential for an alternative voice to challenge it. This pluralistic approach lends itself well to the aim of qualitative research to uncover a broad spectrum of positions rather than discover which position is held by the most people. The concept of conflictual consensus can be put into practice in a research setting by inviting the participants to challenge each other’s visions, actions and opinions, and emphasising the arguments over the conclusions they lead to.

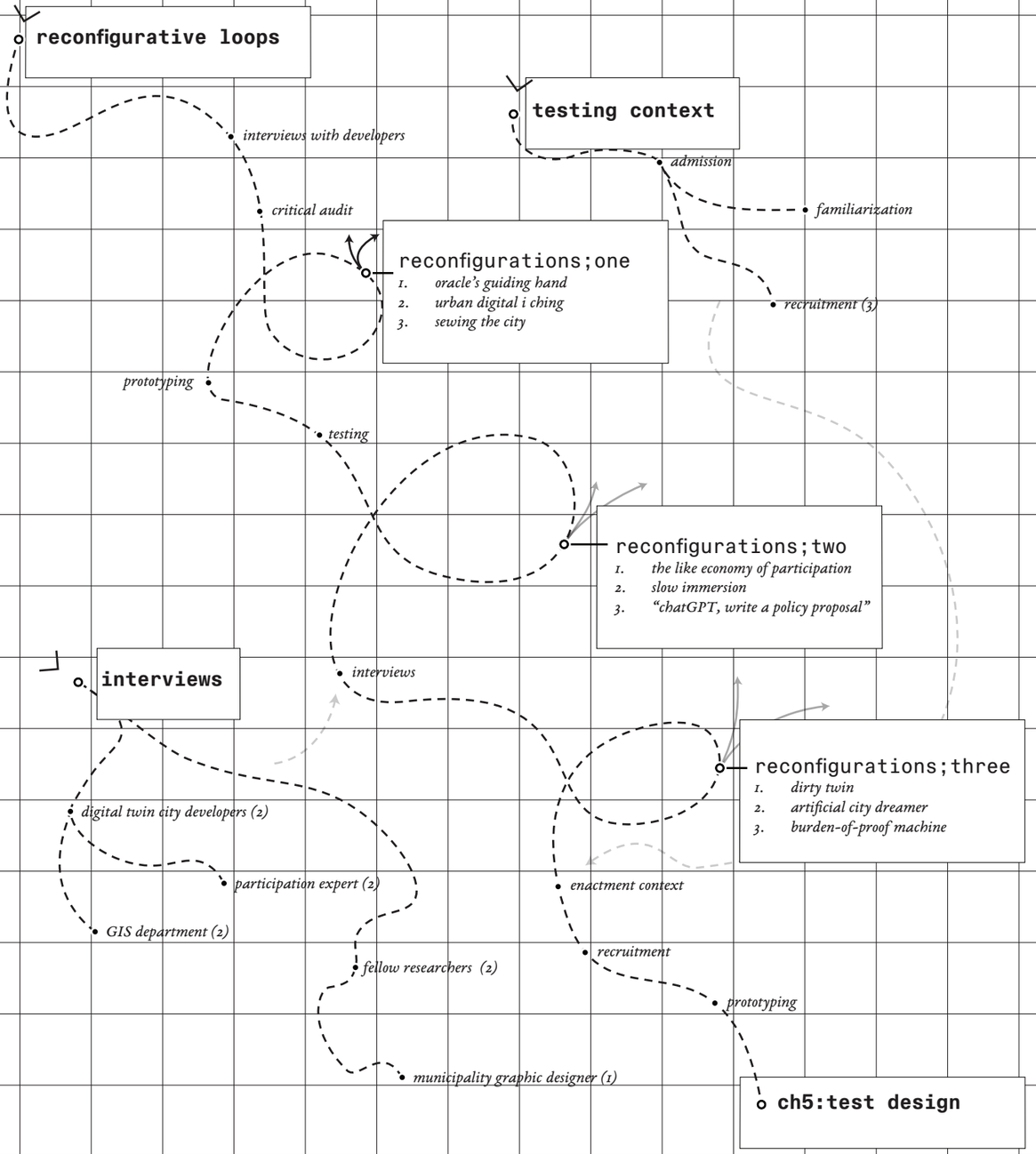
› **This chapter laid out the two core methodologies that I used to answer the research question, Speculative Enactments and Adversarial design. It ended by explaining how they work in conjunction. The next chapter explains in detail the process by which I executed this hybrid methodology.**



Fourth chapter;
Design Activities

This chapter explains the process of how I designed my sessions' speculative scenario and prototype. First I explain the design process which consists of three divergent and convergent loops, informed by expert interviews and familiarisation with the testing context, happening in parallel. For each loop the different reconfigurations are presented and I explain why and how I chose to continue with which parts of which idea. This leads up to the presentation of the final session design in the next chapter.

chapter sections



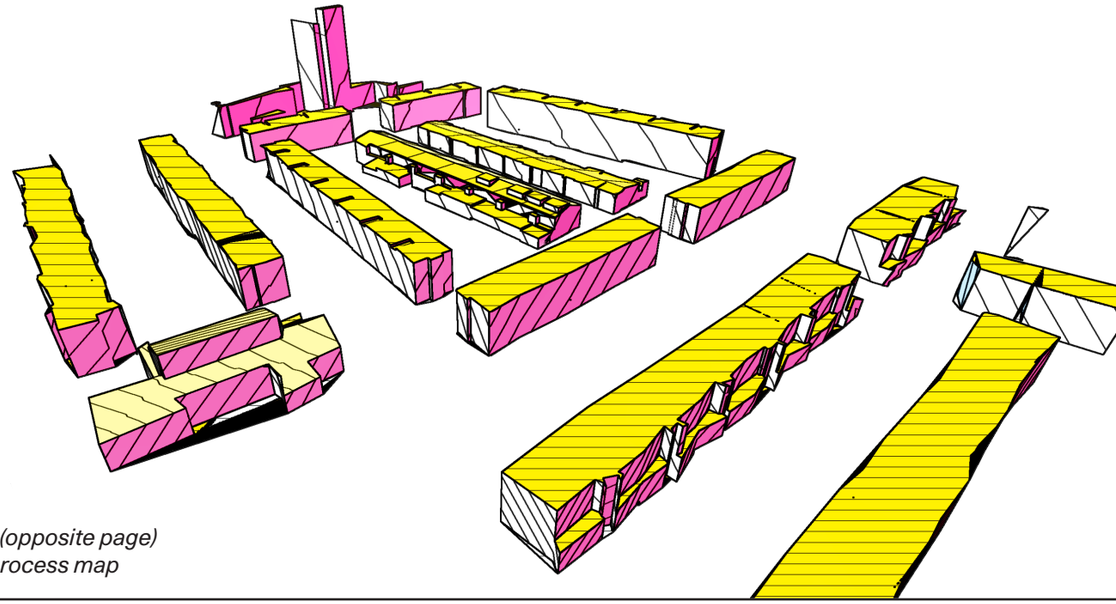


figure 8. (opposite page)
design process map

NOTE ON RECONFIGURATIONS AND ASSUMPTIONS

Chapter four is structured along reconfigurations of the urban digital twin for participation that I developed. Per loop I present three reconfigurations and for each reconfiguration I first present an assumption underlying the current configuration of urban digital twins for participation that I aim to challenge. Some of these assumptions were implied in conversations I had with developers, while others I extrapolated, this was necessary since thought about urban digital twins for participation is still in its infancy. None were literally stated outright, and so I can not provide sources for them. They should not be thought of as an accurate representation of the way developers think about urban digital twins, but rather as starting points for a dialogue about their design.

After laying out the assumption I provide my critique of that assumption followed by a concept that embodies that critique or otherwise makes it concrete.

section 4.0>1: starting point

To find a starting point from which to define reconfigurations I wanted to perform a critical audit of the way the urban digital twins for participation are currently envisioned. With the current obscurity of urban digital twins in the mainstream this meant looking at the development side. To this end I conducted interviews with developers of urban digital twin initiatives in Rotterdam and The Hague. The Hague was an obvious choice since I was already in contact with the project supervisor, and Rotterdam had already attempted a pilot using their digital twin for citizen participation in spatial planning, so I deemed it valuable to speak to the developer of that subproject: Co-creatie in de Digitale Stad.

INTERVIEWS WITH DEVELOPERS

Both interviews were conducted online. The interview with the Rotterdam developer provided a good overview of how their pilot went and the actors and technology involved in setting it up. As part of the redesign of a public square, they had set up an online platform accessible through a QR-code present on the square. On this platform residents could design their own version of the square using street furniture from the Rotterdam Style Library and the model tells them if this is impossible due to underground objects, they can then upload them for others to see and give “like” ratings to.

It was this approach and the attitude towards it that would later come to form the core of my own critique, as the developer would enthusiastically explain how the platform was viewed over 100 times, far more than the meagre attendance of most “*bewonersavonden*” (lit. residents’ evening, traditional settings for participation in the Netherlands).

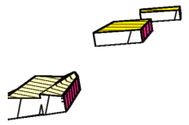
Talking to the developer in The Hague, which has not yet set up any participatory applications, I learned they admired the pilot in Rotterdam and thought they would be crazy not to copy it if the technology is there.

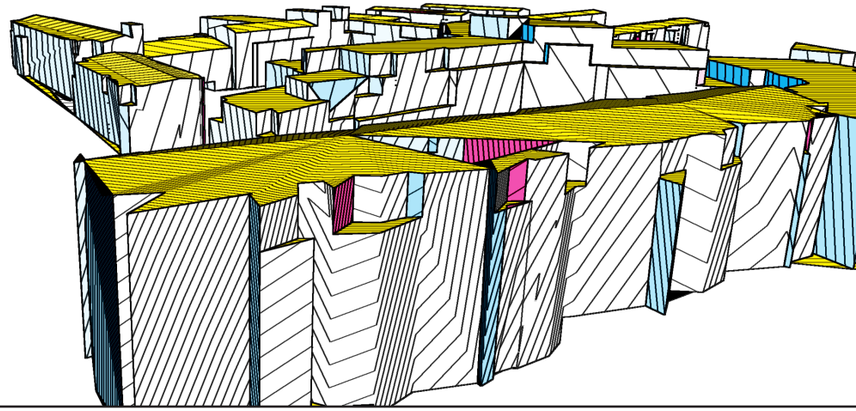
ch4.design_activities sc0>1.starting_point

CRITICAL AUDIT

After sketching out the currently envisioned configuration of the urban digital twin for participation based on the Rotterdam pilot, contextualised with common urban digital twin ambitions such as simulated metrics, I presented this vision to my colleagues. We sat down in four quick, informal sessions to critique it together; these critiques formed the basis for my first set of reconfigurations, and many of the ones that would follow later as well. Recurring criticism included:

- Transparency of the model: who is funding it and how can they influence it?
- Issues with digital literacy: what does it mean for democracy if a participants’ digital skills determine their ability to provide input in participation? Would little boys who play a lot of city builder games (which the current interface seem to be modelled after) rule the city?
- Reductionism: this form of input is overly simplified and loses the reasons why people make suggestions, leaving only the suggestion itself, while the rating system reduces a design to a single number, potentially leading otherwise good ideas to be ignored if they appear in a design that is poorly appraised for being ugly.
- Leaving no room for negotiation: many of the choices that need to be made in a participatory process can not be seen as purely possible or impossible, or good or bad. The discrete nature of the model leaves no room for negotiation; yes, but... rather than no, because...



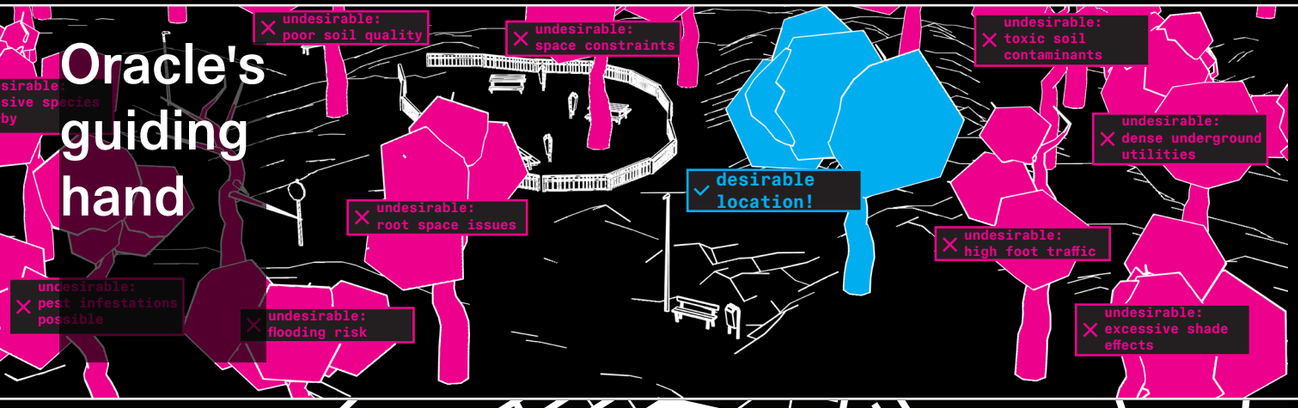


ch4.design_activities sc1.reconfigurations;one

RECONFIGURATIONS; ONE

As the first reconfigurative loop, this one was still very exploratory. Neither the context nor the form of interaction was set in stone yet, so all of these were subject to scrutiny.

Oracle's guiding hand



[selected]

ASSUMPTION: by giving context and predictions calculated through the digital twin we can level the playing field between citizens and experts without needing them to understand how to calculate the results of certain interventions.

CRITIQUE: if citizens don't understand the results presented to them by the model, they can be steered towards certain choices without being able to contest why those are or aren't preferable. This may lead to technocratic decision making with the veneer of participation, or worse, the parameters of the model could be tweaked to prioritise a solution that is only beneficial to certain actors, i.e. the tyranny of participation.

CONCEPT: enlarge the issue. create a city builder that provides such restrictive feedback on actions that there is only one acceptable solution.

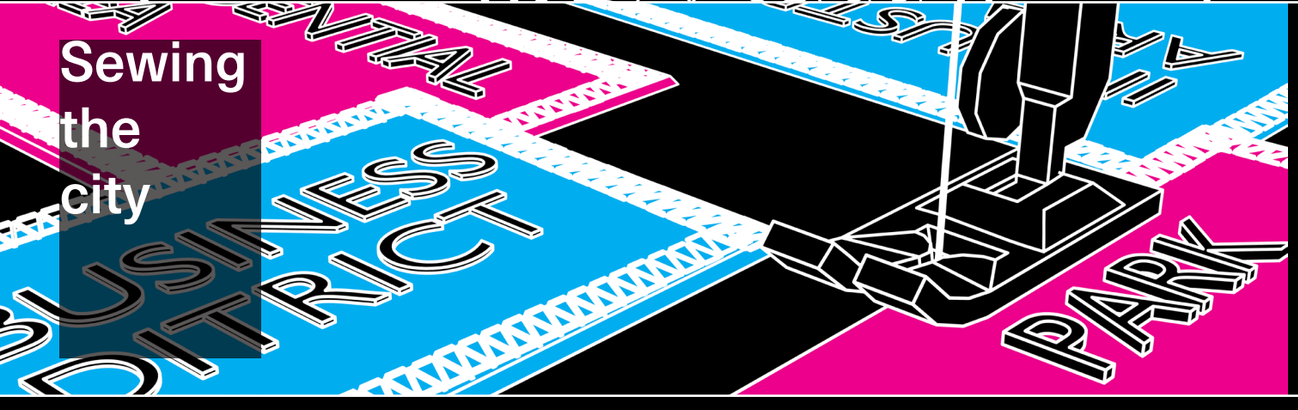
Urban Digital I Ching

ASSUMPTION: by calculating the costs and benefits of certain spatial designs we can guide the participant to make well-informed design decisions.

CRITIQUE: similar to reconfiguration 1, showing benefits as one-dimensional "good or bad" quantifications can make the process less democratic by guiding participants.

CONCEPT: provide an alternative: the system does not say "air quality++" or "budget--" but instead gives neutral predictions on topics that are more controversial, ambiguous, or commonly left out of decision-making processes (the remainder), such as: auspicious feng shui, skateboard friendliness, or number of worm species.

Sewing the city



ASSUMPTION: letting participants provide rich input with complex digital tools will make the process more democratic.

CRITIQUE: the urban digital twin participation bestows more power upon people who are experienced with similar digital tools; a kid who plays Cities: Skylines will be able to create a much more detailed design than a grandmother who doesn't use the internet, so the outcomes of participation may disproportionately benefit gamers.

CONCEPT: provide an alternative: instead of modelling the interaction after city-builder games, base it on a technology that is familiar to a different demographic, such as sewing machines or a card puncher.

section 4.1>2: between one & two

I chose to continue with the oracle's guiding hand reconfiguration, as it represented a critique that was at the heart of what distinguishes urban digital twin participation from other methods: their predictive capability and its effect on participants. Furthermore, the approach to critical design, enlarging a perceived issue to materialise it for discussion, would be the most interesting to try in this early stage when failure was still permissible.

PROTOTYPING

I built my first prototype as a fully digital application (figure 10) in Unity, a game engine that is often used for urban digital twin applications. I stuck close to the present design language of the Digitale Spiegelstad (figure 11) to draw attention to the parts that were different. I chose a set of uncontroversial indicators (air quality, traffic flow) that the system would predict based on the participant's design. For ease of prototyping the only possible interaction was for the participant to place three types of trees, as many of them as they wanted.
This was in part a prototype for the reconfiguration, but mostly an experiment to see what urban digital twin techniques I could imitate or fake. The building models were displayed by reading from CityGML files, the format used for storing 3D models of most Dutch cities, and used by the Digitale Spiegelstad. The predictions were entirely faked using something called perlin noise (Perlin, 2002), this is similar to white noise as seen in TV static but with smooth gradients, see figure 9. Imagine laying this picture flat on the square, and if a tree is placed on a very light pixel, the predicted value increases by a lot, and if it is placed on a very dark pixel it decreases by a lot. I generated such a noise field for each tree and each prediction value, this let me create the illusion that the model made calculations based on the location where you put an object, and this technique I would reuse for my later prototypes.

figure 9.
perlin noise

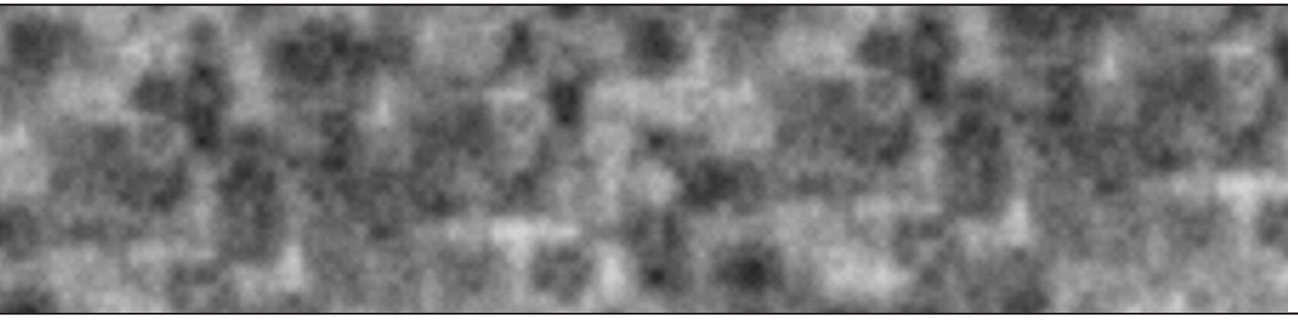


figure 10.
first urban digital twin prototype

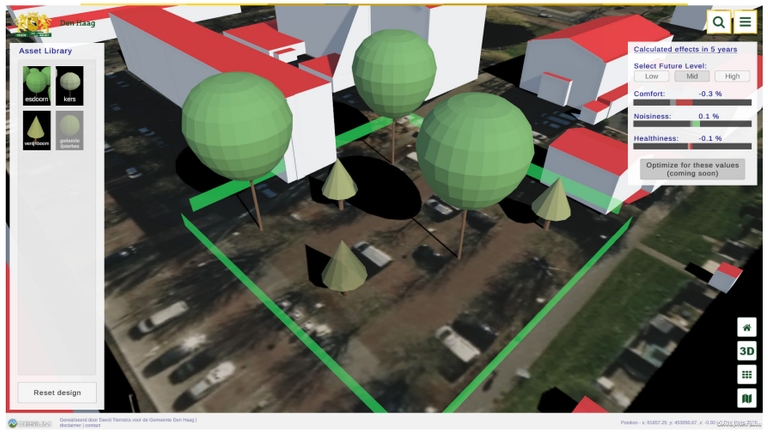


figure 11.
the same location seen in the Digitale Spiegelstad

PRELIMINARY TESTING

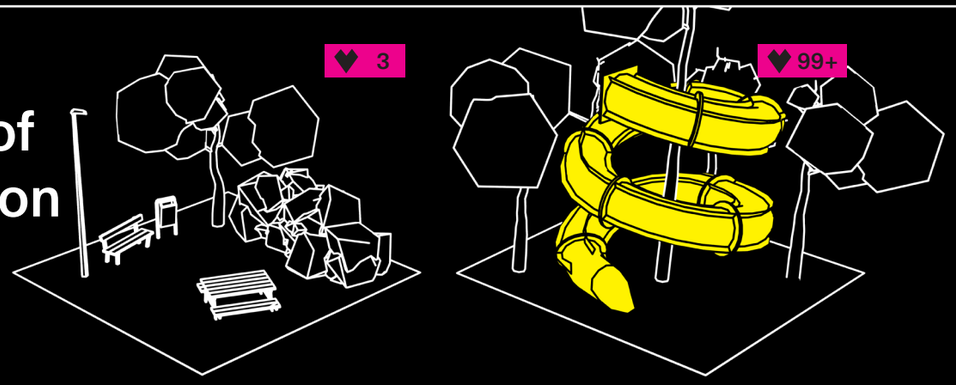
I tested the prototype in an interview with a participatory advisor for The Hague, and this test was a colossal failure. The prototype failed to stir any kind of discussion about the potential for urban digital twins to generate support bases for technocratic decision making, but instead stranded on issues with the controls of the prototype and the unrealistic predictions the model was making. One interesting finding was that the participant "just kept placing things to see what the sliders do," suggesting at least a slight potential for urban digital twins to stimulate experimentation. More importantly, this test taught me that if my final sessions were to be a success, I needed a way to circumvent the struggles with UI that had so plagued this one. With this in mind I started a new loop of reconfigurations.

ch4.design_activities sc2.reconfigurations;two

RECONFIGURATIONS; TWO

This loop tried to examine the circumstances around which urban digital twins for participation may emerge and the way they are used to translate input to policy, and subverting them or blowing them out of proportion.

The Like economy of participation

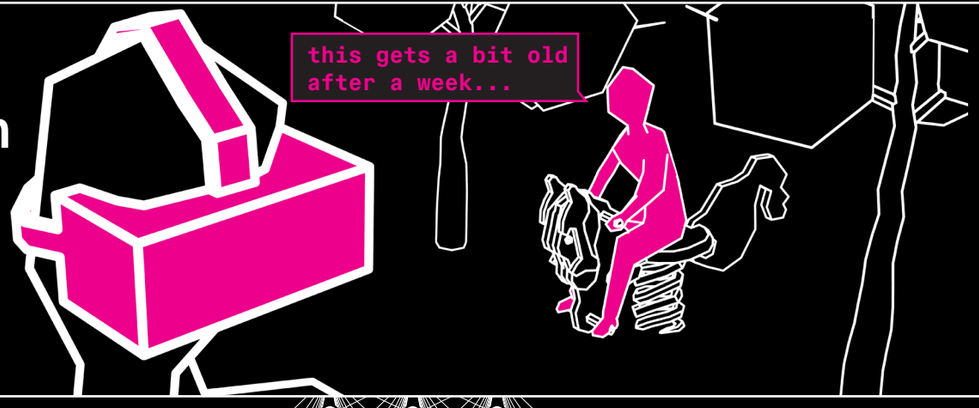


ASSUMPTION: using urban digital twins municipalities will be able to collect input cheaper and faster from much greater groups of people than through traditional means.

CRITIQUE: collecting likes on a design carries a fraction of the rich meaning conveyed in a traditional group conversation, basing decisions on such processes may lead to designs that are good at getting likes without actually serving citizens' needs.

CONCEPT: all participation is conducted through an Instagram-like application where users are shown "trending" policy proposals. An interactive scenario reveals the superficiality of the most popular proposals that are chosen in favour of well-thought-out ones.

Slow immersion

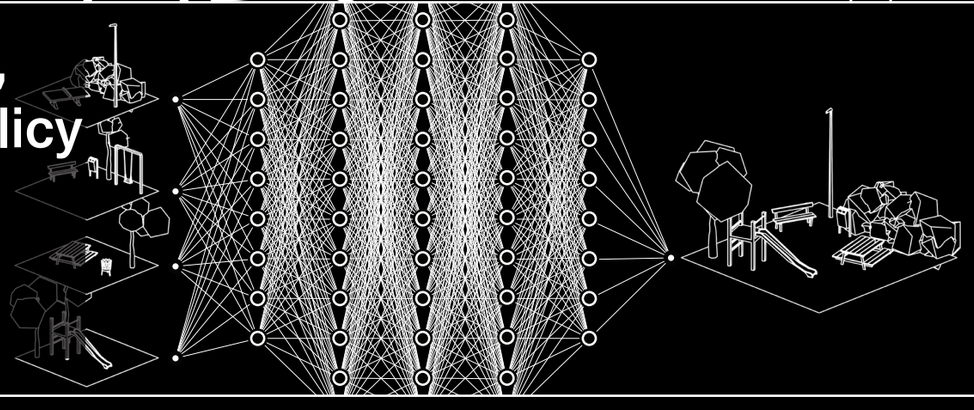


ASSUMPTION: [same as previous]

CRITIQUE: [same as previous]

CONCEPT: instead of accelerating the issue, it shows an alternative future where urban digital twins are instead used for very slow, mindful participation where citizens sometimes spend days living through a simulation of a proposal before casting a judgement on it.

"ChatGPT, write a policy proposal"



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ASSUMPTION: urban digital twins' aggregate data modelling capabilities can be used to process citizen input on a large scale and thus accelerate participatory processes.

CRITIQUE: when the model is left to interpret the input provided by citizens their knowledge and desires are thrown into a black box and it is not sure if what emerges is what they intended to happen.

CONCEPT: an extrapolation of this future could already be quite concretely explored by hosting a roleplay in which participants are tasked with giving their input on a pending policy decision and at the end all their suggestions are fed to a "policy-writer" language AI that immediately comes up with a proposal that claims to integrate all their knowledge and wishes.

ch4.design_activities sc2>3.between_two&three

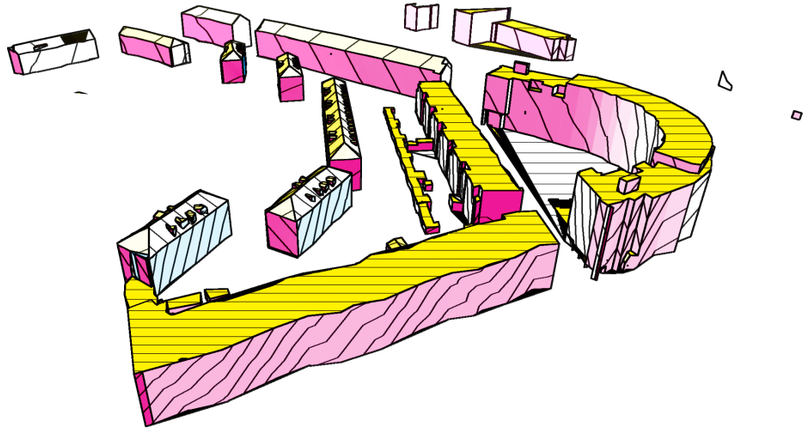
section 4.2>3: between two & three

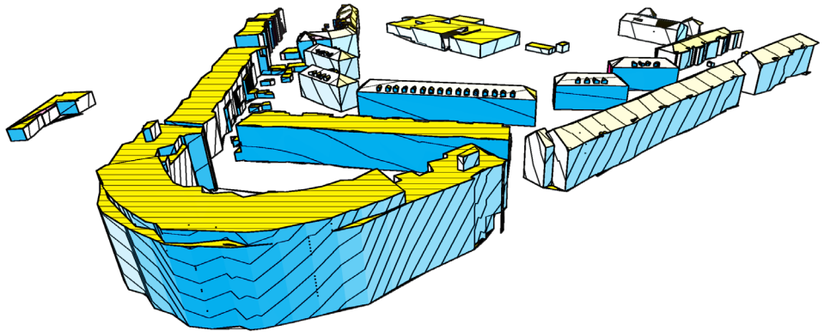
Since all reconfigurations addressed similar criticisms, I chose to continue with the third because it could be integrated well with my existing concept, while the other two would have required a drastic overhaul that made it more difficult to simultaneously address other criticisms. During this phase I had no time to prototype and test the reconfiguration and rather had it contribute to the original concept, being explained in the scenario as the mechanism by which the participants' contributions will be processed, rather than enacting it with a prototype.

INTERVIEWS

I conducted five interviews with experts during this phase: I spoke with two other master's students who were researching urban digital twins for participation in their thesis. This provided me with much fresh insight and inspiration for further reconfigurations, specifically regarding transparency about the translation from input to policy. I also conducted an interview with two members of the GIS department of the city, who helped give me a better picture of the kinds of visualisations, analyses and predictions that could potentially be used in participatory processes using the twin, as well as an approach to introduce lay people to the sometimes overwhelming data shown through GIS applications. Lastly I talked to a graphic designer working for the municipality, which helped me position the aesthetics of my own prototypes.

I tried to apply as many of these new insights as possible into my final reconfigurative loop.



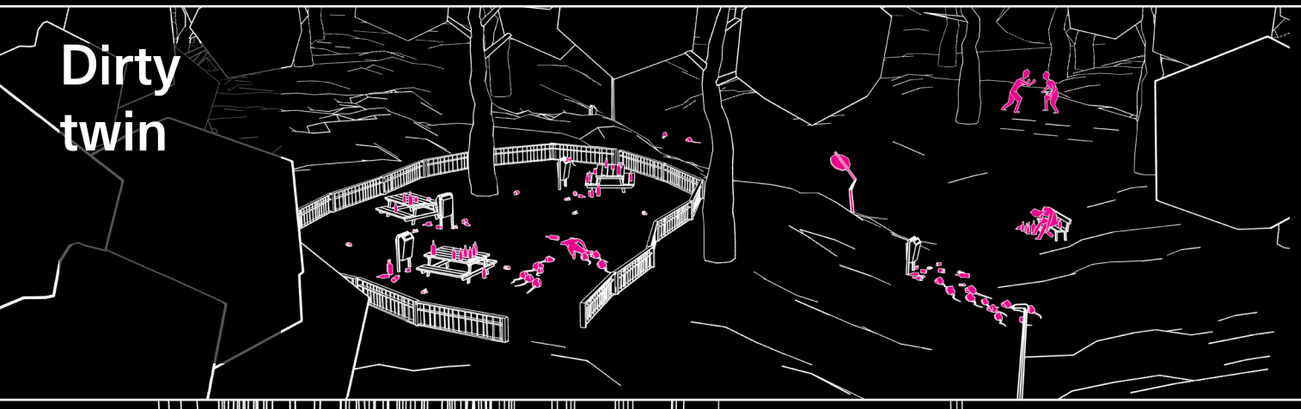


ch4.design_activities sc3.reconfigurations;three

RECONFIGURATIONS; THREE

This loop focused on details or specific features of the urban digital twin for participation, inspired by the interviews of the preceding phase.

Dirty twin



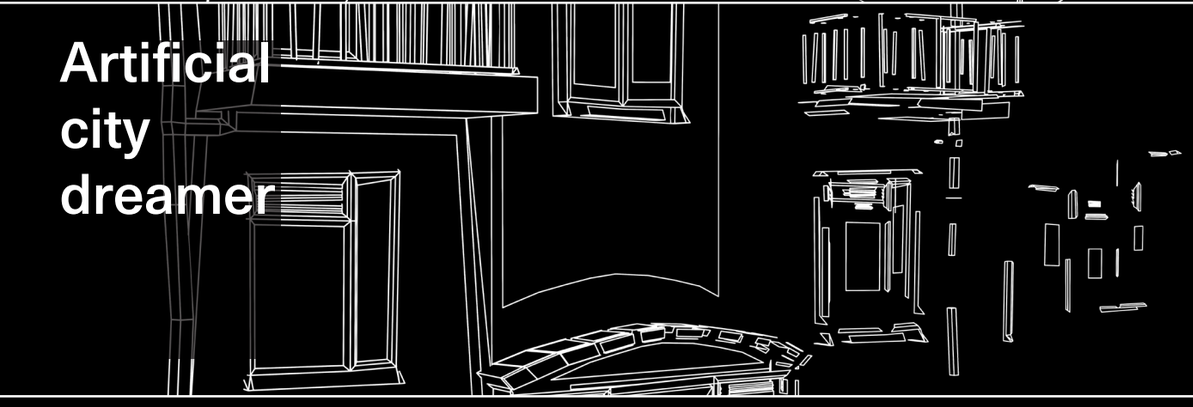
[selected]

ASSUMPTION: by providing pretty and immersive visualisations, urban digital twins give citizens an accurate picture of what the city looks like or could look like.

CRITIQUE: urban digital twins only show the parts of a city that are easiest to measure and, like most architectural renders, easiest on the eyes.

CONCEPT: an urban digital twin that specifically emphasises the parts often left out of the configuration because they are difficult to measure or people would rather not look at them, such as rats or populations of homeless people, perhaps focusing on showing some rather than trying or claiming to capture all and instead cherishing the imperfection of the data.

Artificial city dreamer

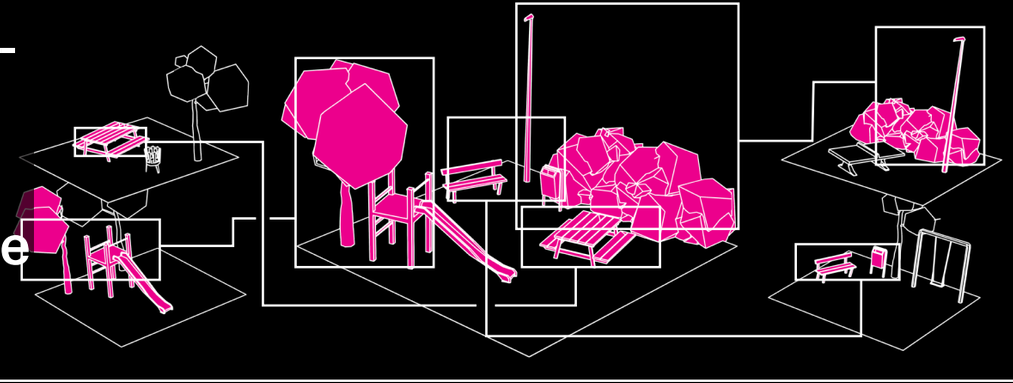


ASSUMPTION: during participatory processes for spatial planning, participants should stick to using assets and interventions that are preselected by the municipality for feasibility of execution.

CRITIQUE: participants can come to agreements with developers or come up with ideas far outside what can be contained in a prepared set of inputs.

CONCEPT: AI generation of 3D models and processes can be used to visualise alternative ideas. This is less an embodied critique and more an open exploration as I potentially see positive and negative consequences to this idea.

Burden-of-proof machine



ASSUMPTION: urban digital twins can be used to collect more realistic input from citizens. By presenting them with intuitively visualised predictions and trade offs they can make more informed decisions and give input that is easier to work with.

CRITIQUE: this kind of process should strive for symmetry. If citizens are expected to give more thoughtful and realistic input, policymakers should also give this input more weight in decision-making.

CONCEPT: after citizens have submitted their designs for a space, the digital twin challenges the developer to actually use these in their final design in concrete ways by providing a series of tools to link features of the final design to features of submitted designs.

section 4.3>: final activities

For the final loop I chose to implement parts of the dirty twin, adding predictions to the model that could make it more provocative and elicit a richer discussion.

ENACTMENT CONTEXT

At the same time that I was developing reconfigurations, I was still struggling to gain access to a context where I could run my enactments and interviews. In order to achieve a high level of embeddedness and consequentiality for the participants, I was still searching for a place where a real participatory process was taking place that I could piggyback on. Eventually I was directed to the redesign of a playground in Moerwijk, Den Haag, which would make for the perfect testing context for urban digital twins and participation. The culturally diverse neighbourhood provided a rich group of potential participants and the highly spatial nature of the project lent itself well to participation with urban digital twins. I had multiple meetings with stakeholders in the project and attended a work group meeting where it was decided that it was fine for me to conduct my research in the context of that project.

RECRUITMENT

There was no designated group of citizens providing input to the project, so for recruitment I would join the urban planner involved with the project to a neighbourhood party taking place on the actual playground to hopefully find residents willing to participate. I brought a poster and flyers (fig. 12) to this party to illustrate my research and to sensitise participants to the enactment, in the end recruiting six participants to three sessions, two participants each. Unfortunately the second session had to be cancelled due to a storm. For the third one the participants did not show up, but people who were standing outside agreed to join me instead. I did another round of recruitment on the street, though sadly the residents that agreed to participate once again did not come to the session. Fortunately I was referred to a group of seven participants that joined me for the final session.

figure 12. counterfactual invitations used in recruitment

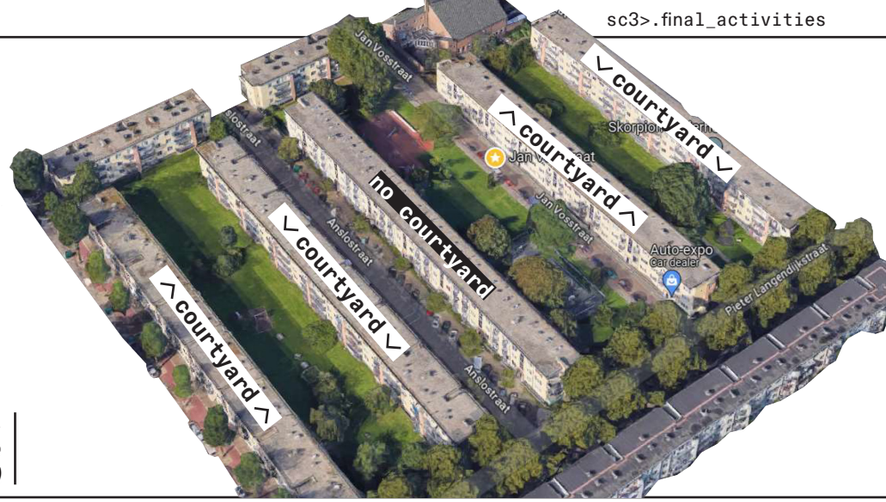


figure 13. Jan Vosstaat (source: Google Maps)

MOERWIJK

To set up an enactment that was relevant and consequential to its participants, it was important to embed it carefully in the context of Moerwijk. Moerwijk was planned as a labour district in the 1930s but most of it was built in the Dutch “reconstruction” (*wederopbouw*) period after World War II, which focused on building large quantities of housing in a short period by experimenting with industrial building techniques, this resulted in repeated lanes of three- to four-storey housing blocks with shared courtyards in between rather than individual gardens (‘s-Gravenhage, 2014). The Jan Vosstraat, the street in which the playground is situated, serves as one such courtyard, with the caveat that it is publicly accessible and has a street running along it (figure 13), making it at the same time its residents’ only garden, a public playground for children, and a street where, as I have been told by residents, cars tend to pass at well over the 30 kph speed limit.

In the decades since its construction, most of the original residents and their children have moved away leaving cheap houses that have come to house low-income families with children (‘s-Gravenhage, 2014). According to data from the municipality, Moerwijk, along with most of Den Haag Southwest, has a low socio-economic status compared to the rest of Den Haag (Gemeente Den Haag, 2023) and is often characterised as a disadvantaged neighbourhood (*achterstandswijk*) which in recent years has led the municipality to invest in social programs and renovations in the area. Both the redevelopment of the Jan Vosstraat playground and the Thesis Hub project this thesis is associated with should be understood in the context of this initiative. Furthermore, the neighbourhood is culturally diverse, with 58% of the population in 2014 having a non-western migration background (Blaster, 2016). Non-western in the Netherlands being defined as coming from a country outside Europe, North-America, Oceania, Indonesia or Japan.

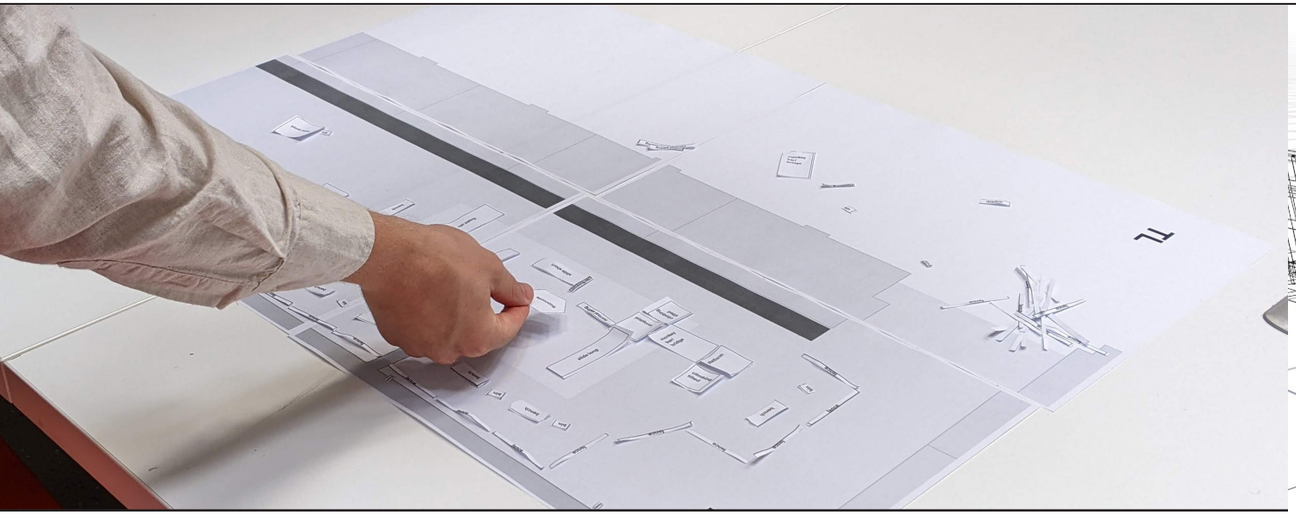


figure 14.
tests during development using paper prototypes

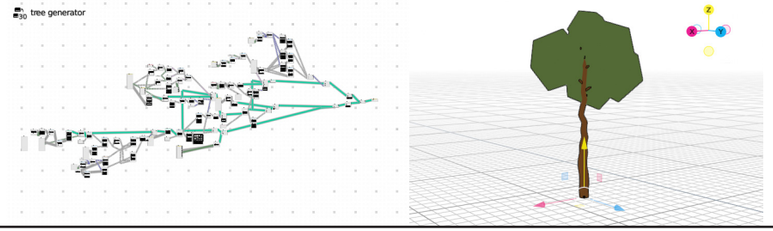


figure 15.
tree growing algorithm (zoomed out)

PROTOTYPING

In between preparations and recruitment I was busy trying to finalise my enactment scenario and prototype for the sessions. While I could largely reuse the old prototype for calculating and displaying predictions, I decided I needed a vastly different form of interaction. To bestow a more immersive character upon the interaction while still feeling constructed or scanned by a computer, I used Blender to create low polygon models of the assets participants could put down (figure 16) and the scene around the playground and populated it with algorithmically generated trees of different sizes (figure 15). As shown by the previous test, I could not rely on a digital UI, so my final idea for solving this issue was to cut playing pieces representing the objects participants could put down from foam (figure 17).

ch4.design_activities sc3>.final_activities

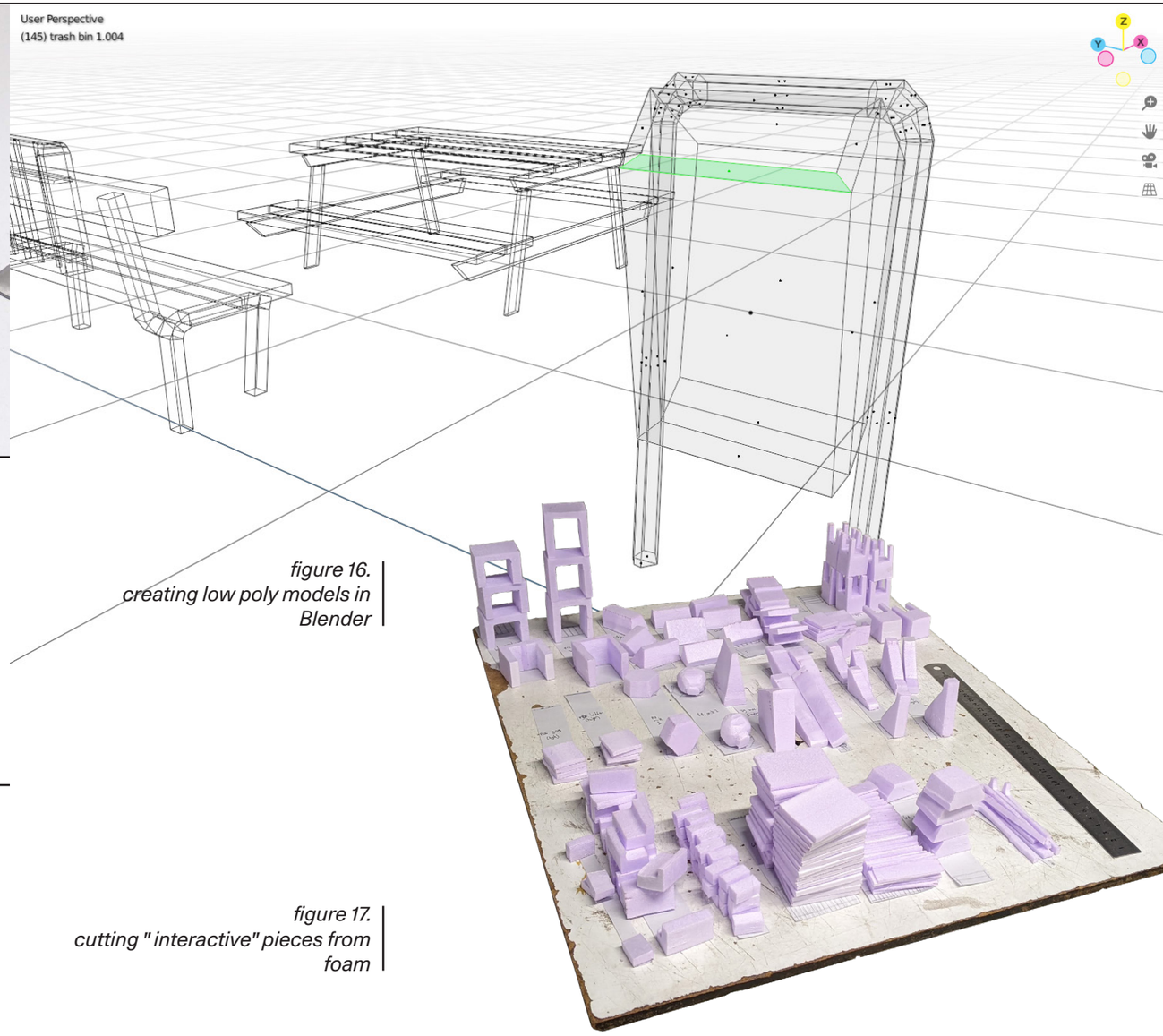
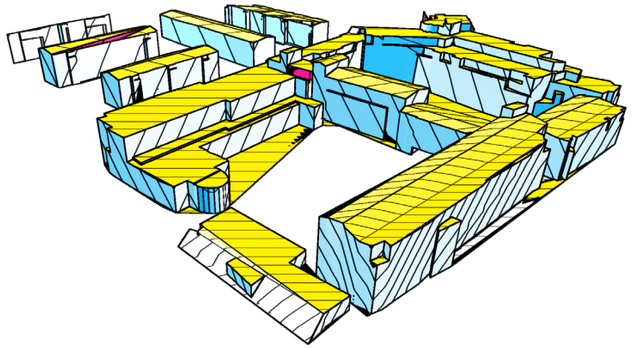


figure 16.
creating low poly models in Blender

figure 17.
cutting " interactive" pieces from foam

> These activities resulted in my final scenario and prototype as presented in the next chapter, where the reasoning behind the specific choices is explained in detail.



Fifth chapter; The design

This chapter explains the final research setup, starting out by giving the overall process of the sessions, and then presenting the scenario for the enactment, and the prototype that was used, while explaining the various design choices that were made.

chapter sections

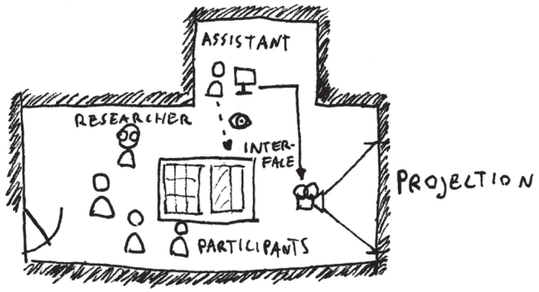


figure 18.
test setup

section 5.1: session procedure

My research sessions consist of two phases: an enactment using a prototype and an interview. The setup can be seen in figure 18 and the structure is as follows:

1. Participants are briefly introduced to the topic of UDTs and to the structure of the session. They are invited to join the enactment, playing themselves in a scenario utilising technology that is not (yet) real. They are given a clear disclaimer that while the moderator will play the part of a municipality researcher, they do not actually represent the municipality in any capacity.
2. Participants are asked to sign an informed consent form (see appendix B).
3. Enactment:
   i. The session moderator, in character, welcomes the participants and explains the how and why of the project to them.
   ii. Together, participants furnish the playground, The moderator is present to answer questions and take notes but does not get involved with the design.
   iii. An assistant translates the participants designs to digital space in real-time. As time progresses more predictions are calculated and revealed to the participants.
   iv. Eventually time runs out and participants are asked to agree to submit their design to the municipality and are shown a fake link to see how it is used in the final plan.
4. The moderator announces the end of the enactment and steps out of character, re-emphasizing that the interaction was not a real participatory process and the design was not really submitted.
5. The moderator conducts a semi-structured interview with the whole group.

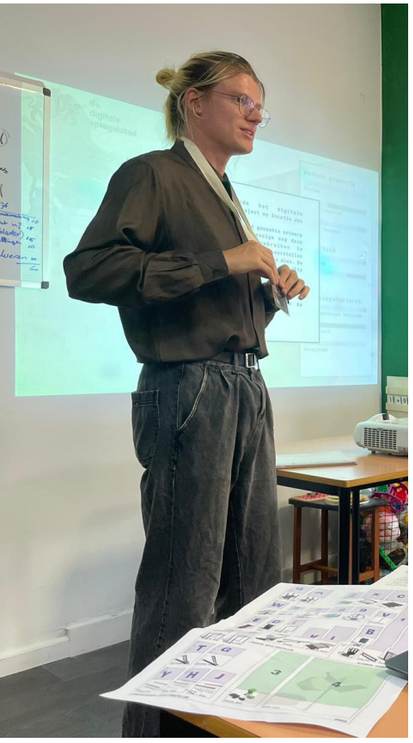
DATA COLLECTION

During the tests data was collected in three forms: (1) an audio recording was made, starting after step 2, when all participants had given their consent and ending at the official end of the interview. (2) Photos were taken of the prototype as participants interacted with it, and if specific permission was given also of the participants (these have been censored in the report). (3) Screenshots of the assistants view (figure 19) were taken to assist later reconstruction of their designs.

figure 19.
assistant screen

figure 20.
interview photo

section 5.2: enactment scenario



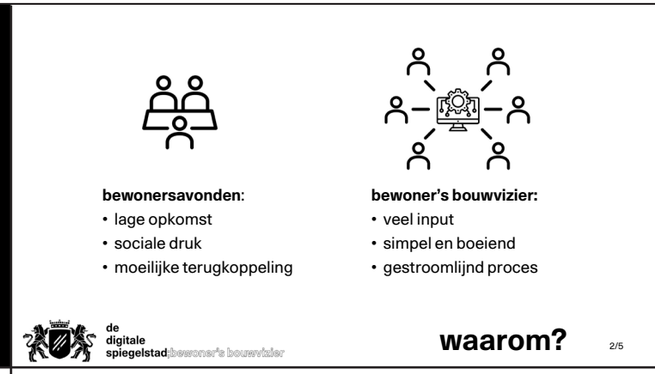
Participants were presented with the following scenario:

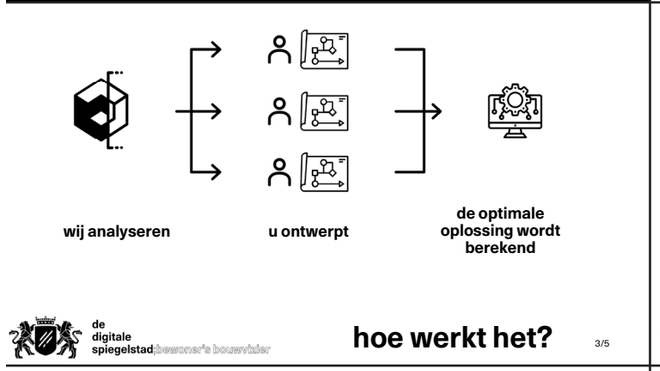
They had been invited as one of several groups of residents to give their vision on the redesign of the Jan Vosstraat using an experimental new system called the Bewoner's bouwvizier, which would let them create well-informed designs by providing predicted metrics of what the future effects of their design will be. All designs will after submission be processed by an AI which then creates a final design proposal representing the choices embodied in the citizen's designs, within the constraints set by the municipality. The reason for this is that following the introduction of the Omgevingswet, obligatory participation quota have grown to the point where civil servants are no longer able to meet them by traditional means of outreach, so they are looking for new solutions to collect and process large amounts of rich citizen input using minimal manpower.

The scenario emphasises plausibility and embeddedness over speculation and imagination in order to elicit actions from the participants that are more representative of how they would act in a real situation, and to make the concept of urban digital twins for participation highly concrete as a grounds for discourse during the interview. The reason for this is that the research is to test and critique the potential risks and benefits of an emergent technology, rather than to inspire imagination on the part of the participants. The names and symbols used stay close to the style characteristic of the municipality, while the graphic style is different enough to prevent confusion.

To achieve this level of embeddedness, the researcher plays a researcher and the participants play themselves.

figure 21.
roleplaying as a civil servant





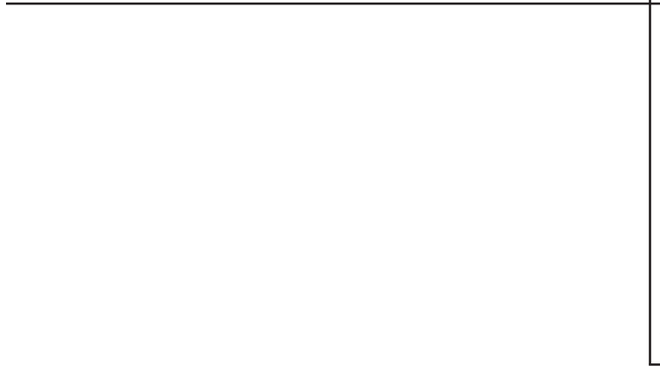


figure 22.
participants are introduced to the scenario through fictionalised slides

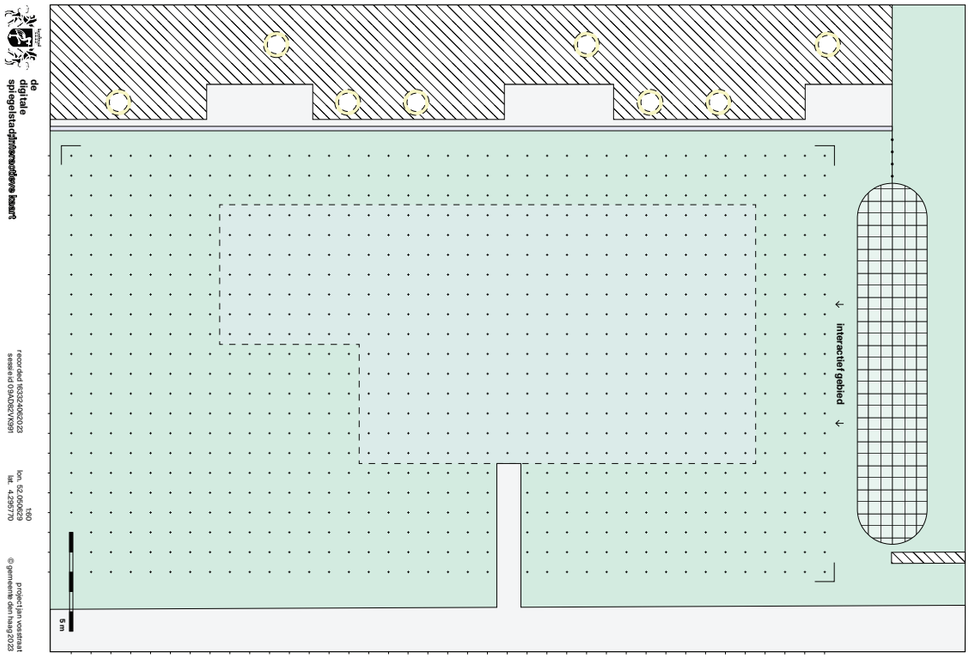
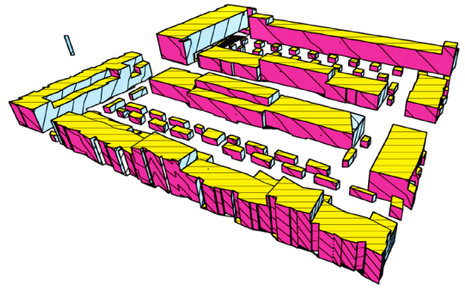


figure 23. (opposite page) interactive map



section 5.3: prototype

The prototype used in the enactment consisted of an analog and a digital component. Participants were given a premade set of physical pieces (figure 24) representing different objects that could be used to build the playground, they could place these on a map of the playground (figure 23) and the system would digitise their design and place it in the digital twin, calculating various effects their design would have in the future on local metrics set by the municipality, these were revealed over time as they progressed through the interaction.
Results were visualised on street-level view through a camera that participants could place anywhere on the map. Occasionally pop ups would appear informing participants their actions were impossible because of one of three reasons.

In the following section I explain in more detail the various choices that were made in the design of the prototype and the reasoning behind them.

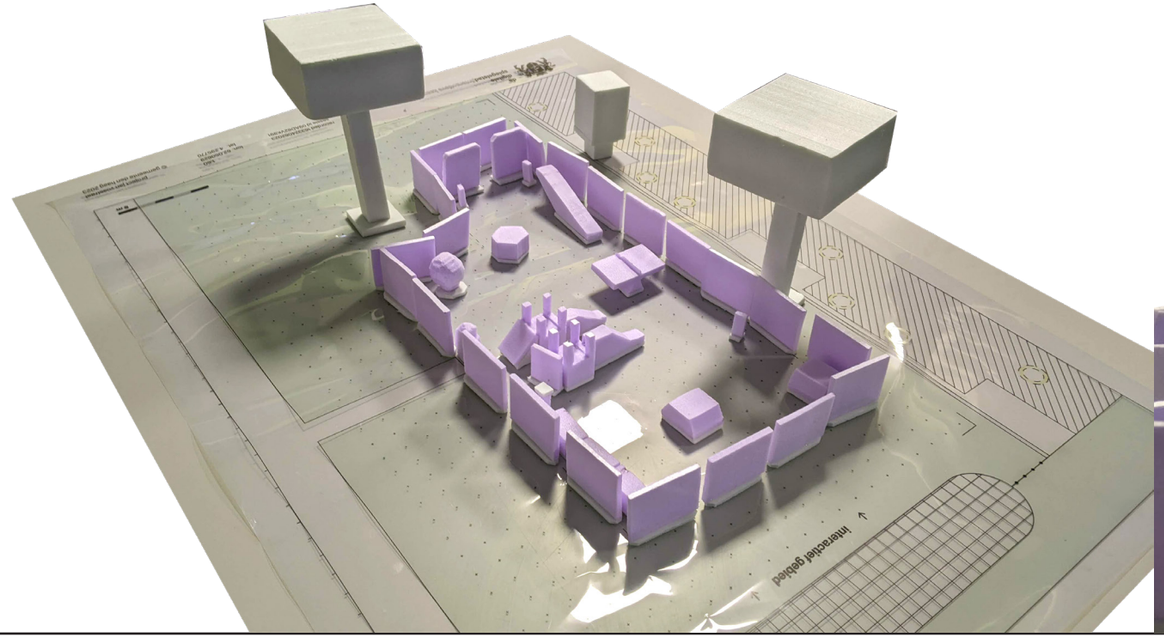
figure 24. analog interface in use

Try an adapted version of the prototype at davidtiemstra.github.io/bouwvizier or by scanning the qr code. Note that this may not yet be operational depending on time of reading.

PHYSICAL INTERACTION STYLE

The decision to use an analog interface and use Wizard-of-Oz (Dahlbäck et al., 1993) to translate this into digital space was made primarily out of practical concerns, as I soon discovered that developing a virtual UI that a group of participants can use together would not be feasible. This itself served as a reconfig uration akin to reconfiguration 1.3: sewing the city, challenging the dominance of purely digital interfaces that disproportionately empower certain groups over others. However, critique of UI design had moved outside my scope so this was not a focal point of the interviews.

figure 25.
analog interface in use



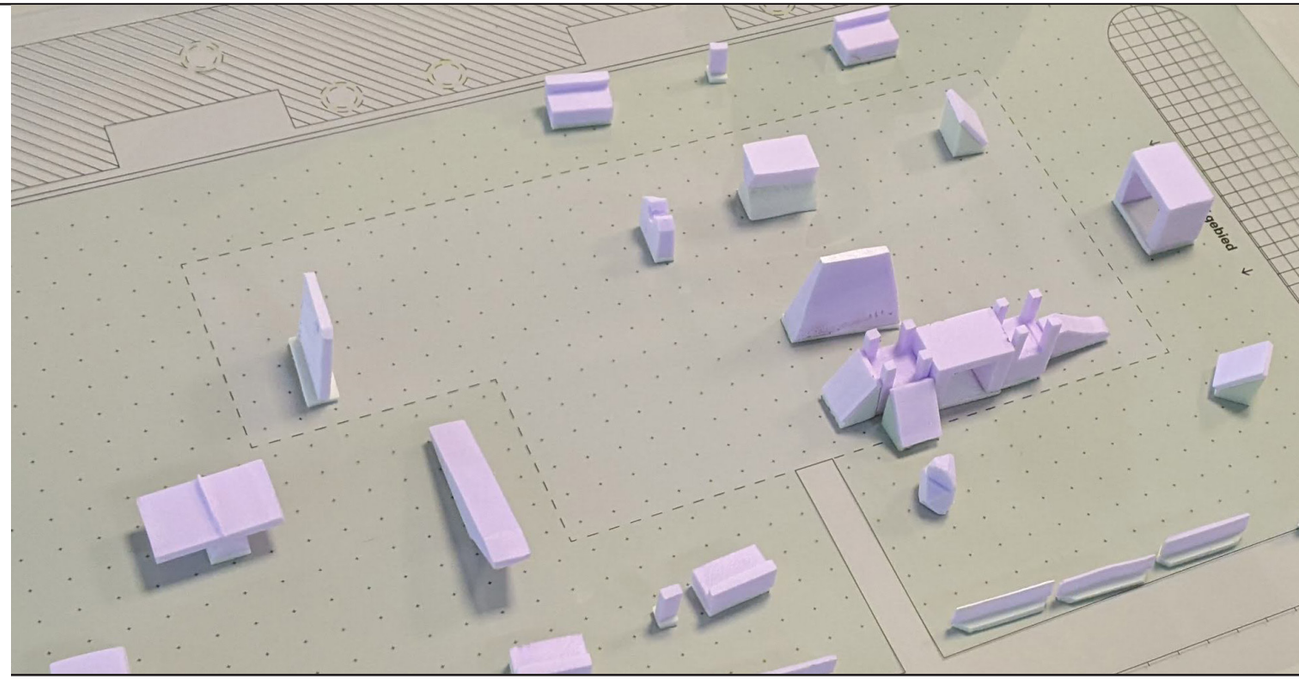
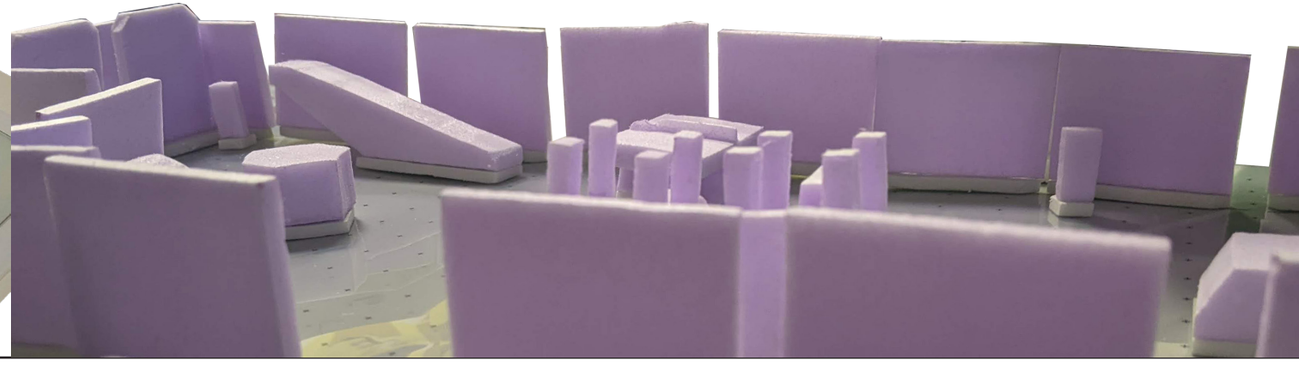


figure 26.
analog interface in use

figure 27.
analog interface in use



ASSET PIECES

Participants were given a selection of 30 different foam pieces they could place on the map, each unique physical piece corresponding to a unique digital asset. This one-to-one relation with physical resemblance was chosen to make the interface intuitive to use, and the exclusive use of predefined assets was inspired by the Rotterdam pilot, which restricted participants to using assets from the Rotterdam style library. This was intended as a challenge: to see if participants would search for solutions outside those offered to them by the system. I wanted to know to what extent the extended palette dictates the participants' decisions, since an urban digital twin can never reasonably offer every solution a participant may come up with, and this could also be an obvious way for developers to influence the outcomes of participatory processes.

The most important asset choices are explained here.

General items (*algemene voorwerpen*)

Outside the category of playground equipment, participants were offered three kinds of seating (*betonnen bankje, bankje, picnic tafel*), each with different costs, to create tension and elicit discussion around budgeting. They were also given a street light (*lantaarnpaal*) and a fire cage (*vuurkooi*), which requires a short anecdote to justify. During prior discussions among the work group for the playground, a fire cage or barbecue spot had been proposed as a way to get fathers to socialise, but after the discussion I had been privately informed by one member that they deemed this a hopeless idea in the context of the large Muslim population of Moerwijk: if fathers were barbecuing by the playground, mothers would no longer come there with their children to avoid causing tension between their husbands. I had not expected this kind of dynamic to hide behind something as innocuous as a fire cage, so I decided its inclusion may lead to a similar cultural debate in discussions. Participants also had access to a trash bin (*prullenbak*) and a low and high fence (*laag hek, hoog hek*), both of which are explained in the section on indicators.

Miscellaneous playground equipment (*overige speeltoestellen*)

As general playground equipment, I included modest selection of varying cost and catering to children of varying ages. The specific selection was based on conversations I had had with local children and parents during the party on the playground, and was meant to be just diverse enough for participants to argue over the choice, but also similar enough for this discussion to rely on non-obvious, local expertise. The inclusion of two roundabouts (*draaimolen* and *draaimolen bol*), for example, may seem excessive, but the playground currently had a "draaimolen bol" and I had heard (unfortunately seen, as well) how children would often hit their head against it after coming off the slide. This was another consideration that was of high importance to parents, but that I had never thought of myself and could not imagine a digital twin coming up with.

Modular playground equipment (*combineerbare speeltoestellen*)

These were pieces that could be placed next to each other to create a custom playcastle. This choice for modularity was made in part to keep the set small, and in part to provide an avenue for creative expression. Other than that the reasoning was the same as for the other playground equipment, including large and high pieces to accommodate structures for smaller and older children and hybrid structures.

Trees (*bomen*)

Trees are nice. Surprisingly expensive, too.

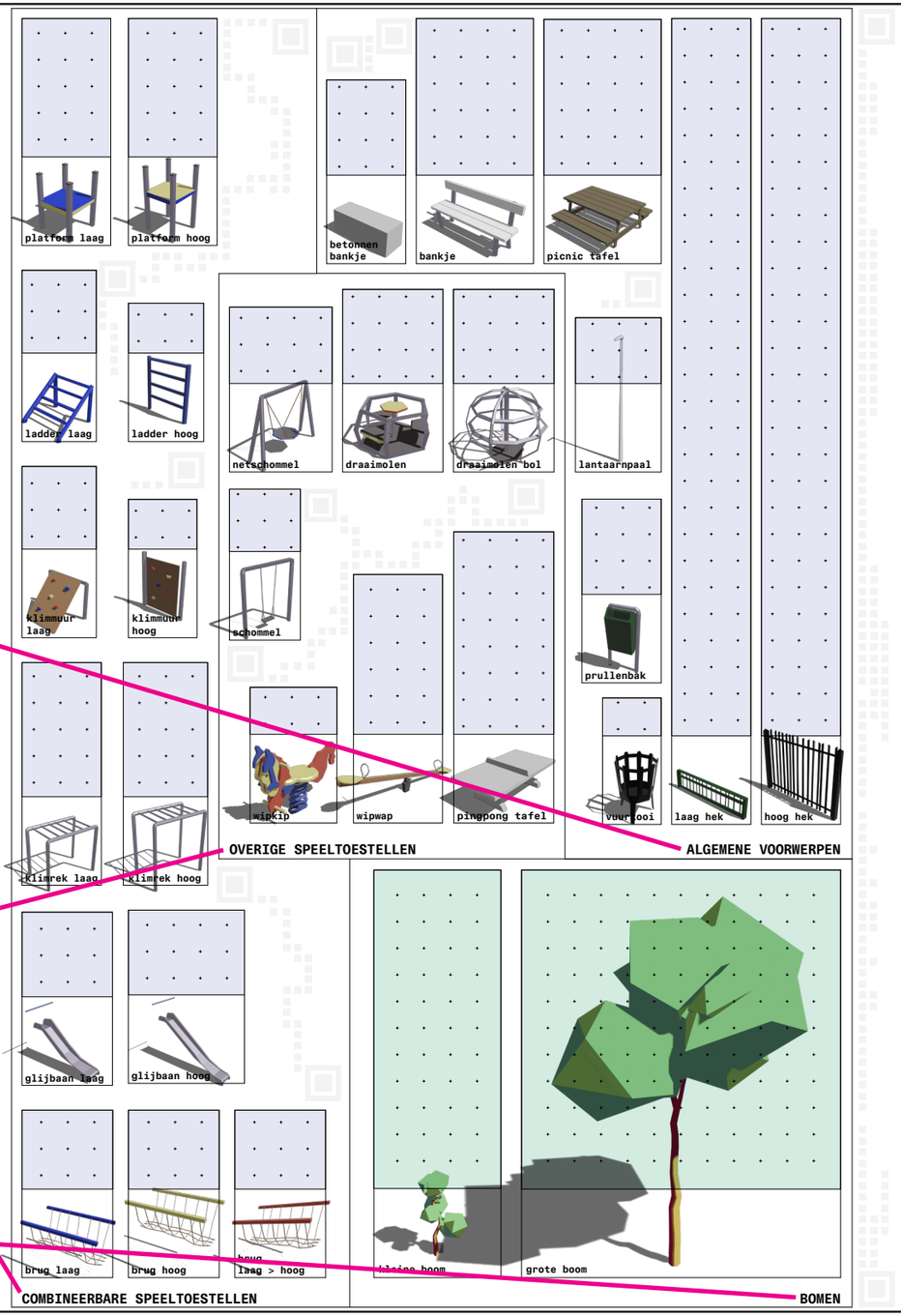


figure 28.
board on which stock pieces were presented to participants

ch5.the_design sc3.prototype

figure 29.
three screenshots showing possible views a participant may encounter

INDICATORS

The core of the urban digital twin's predictive capabilities was manifested in the form of a series of indicators representing various metrics that the twin thought would apply to the future playground, if the participants' design were to be executed. Each indicator was represented as a single bar with no numerical labels, this served multiple ends: for the more quantifiable metrics (cost, litter), it spared me the labour of investigating realistic numerical values and instead let the participants attach their own meaning to them. However, most metrics, exciting for example, were much more difficult to attach a number to, and I was interested to see how participants would deal with this ambiguity. As with previous prototypes, most metrics were based on Perlin noise unless otherwise stated.

The most important indicator choices are explained here.

Wishes municipality (*wensen gemeente*)
These metrics were presented as the wishes of the municipality, each accompanied with a white vertical line which represented the target the municipality had set for the project. During the introduction it was explained that a design which met these targets would be more likely to be executed in reality, confronting participants with a choice between executability and their own ambitions. Hardly a prediction, cost (*kosten*) was shown to confront participants with the most important trade-off involved in the design process. This was suggested by almost every civil servant I discussed the project with, placing it firmly in the presently dominant vision of urban digital twins for participation. Reason enough to investigate it in practice. The target was consciously set unrealistically low to investigate what concessions participants might make to accommodate it, if any. Cost was the only metric for which every asset corresponded to a fixed increase regardless of location. Meeting place (*ontmoetinsplek*) and healthy movement (*gezond bewegen*) were based on the actual project goals set by the sponsors involved.

Playground (*speeltuin*)
These two, exciting (*spannend*) and safe (*veilig*), were two least quantifiable metrics, to challenge the ambiguity and black-box nature of the digital twin. I had intended for them to be inversely correlated to embody another dilemma, this time an emotional one, and perhaps push participants to start questioning the model's assumptions, but I forgot to implement this in the code.

Environmental factors (*omgevingsfactoren*)
Homeless people camping (*overnachtingen daklozen*) and loitering youth (*hangjeugd*) were intended to provoke, and question the exclusion of certain elements from representations of the city, following reconfiguration 3.1: dirty twin. Their potentially controversial nature was also intended to investigate possible discrepancies between the values of the citizens and those they projected onto the municipality. Litter (*straatvuil*) was hardcoded to decrease sharply with the placement of trash bins, providing a simple and intuitive way for participants to influence the model's predictions, despite being based in a gross oversimplification of reality: I was told litter tends to be spread around trash bins as people dig through them for bottles to exchange for container-deposit (*statiegeld*), and in fact the playground's current singular trash bin presents convincing evidence for this theory. I was interested to see how participants would respond when they figured out this technique.

figure 30.
getting a pop-up

figure 31.
all placeable models

POP-UPS

I decided on three different pop-ups that could each appear in objection to any asset placed by the participants: underground object (*ondergronds voorwerp*), negative consequences (*negatieve gevolgen*) and unknown reason (*onbekende reden*). Each of these would prohibit the participants from moving on until they removed the asset. While they were all equally random, their phrasings were increasingly kafkaesque so as to investigate how brazenly a model may try to impose restrictions on participants, and how participants may respond to these attempts.

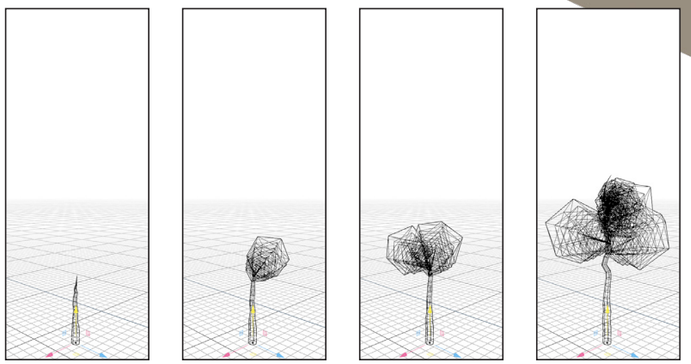
ch5.the_design sc3.prototype

VISUALISATION/ RENDERING STYLE

I modelled most of the 3D models used in the prototype by hand using Blender. They are somewhat crude, intended to look more like a sketch than a render for presentation, to represent a world that feels immersive but like a work in progress; that invites participants to sketch in their own ideas. These stylistic choices, as well as the choice to use a street-level perspective camera, were based on the currently untapped potential I saw for the urban digital twin as a tool for visual experimentation. While something like this had been attempted in Rotterdam, their use of a bird's-eye view camera and realistic models placed on a flat surface with a satellite photo texture resulted in an awkward representation that failed both to be immersive and to be realistic. Lastly, the tree models are not made by hand but generated through an algorithm I built to match the style of the other models while trying to create the impression that the digital twin had simulated the growing of the tree. The algorithm facilitated this growing animation (figure 33) which would have made this effect much more convincing (while at the same time implying a kind of temporality in the simulation, and looking extremely cute) but unfortunately I was unable to get it working in Unity.

figure 32.
jan vosstraat's digital twin

figure 33.
growing a tree on a computer



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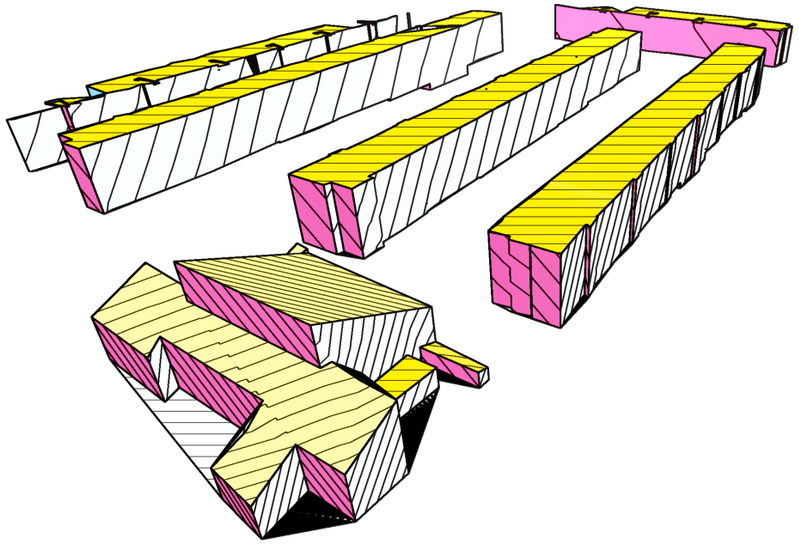


Sixth chapter; *Results*

This chapter summarises the results from the sessions, first explaining the differences between them and then giving an overview of how the enactment and interview proceeded, as well as showing the participants' designs that were made during the sessions.

chapter sections

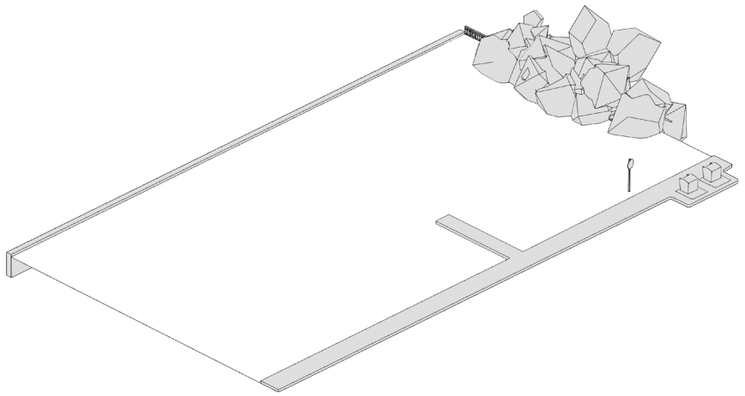


figure 34.
empty template

section 6.1: summary of sessions

Since each of the three sessions had markedly different participants, proceedings and discussions the results are presented separately. An overview of the sessions indicating their key differences is given in table 2.

For each session, a summary of the observations and interview is provided on the left page, with the designs made during the session shown on the right page, both their final design and what it looked like halfway through the enactment.

The empty map without interventions is shown in figure 34.

ch6.results sc1.summary_of_sessions

table 2.
session overview

	#	date	participants	recruitment	notes
	A	27/06/23	1. Hypso*, resident, parent, Dutch speaker	On-site 2 weeks prior	Prototype did not provide predictions.
	B	12/07/23	1. Azi*, non-resident (works in the area), parent, Dutch and Farsi speaker 2. Meri*, non-resident (works in the area), Dutch speaker 3. Zeni*, non-resident, Farsi speaker	On-site on the day	Participant 1 interpreted for participant 3.
	C	24/08/23	1. Axo*, Dutch speaker 2. Bathy*, parent, Dutch speaker 3. Choro*, non-fluent Dutch speaker 4. Demo*, non-fluent Dutch speaker 5. Ekis*, non-fluent Dutch speaker 6. Foca*, parent, Dutch speaker 7. Geodi*, English speaker	Referred through contact person	Language proficiency varied

**Participants are henceforth referred to by these pseudonyms.*

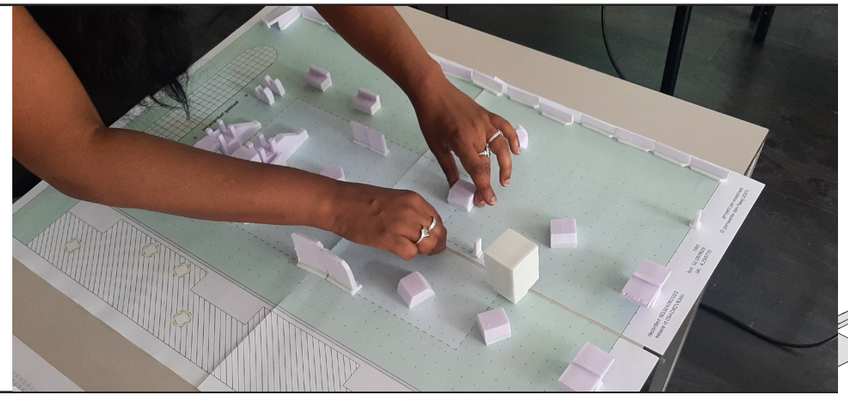


figure 35.
photo from session a

section 6.A: session a

This session differed from the others in that only a single participant showed up, and the prototype did not yet include predictions. This made discussions of urban digital twin futures more abstract, but also provided a kind of “benchmark” against which to measure the sessions that did use predictions.

OBSERVATIONS

- The participant started by describing various dangers of the area and setting up a fence.
- She spent the first half of the session experimenting with different lay-outs for an area for adults, moving the camera frequently to see the results. More problems plaguing the playground came up as she explained the different placements, such as rats around the bushes and goose poop near the benches.
- When building a play area almost every piece of equipment is considered, mentioning reasons why they may be unsuited, and she kept adding pieces to the design. She wanted to add various pieces that are not in the set and improvised (e.g. using a lantern as a sliding pole)
- The participant used the camera to explain various problems, such as trees blocking her line of sight from her window, and a ditch she wanted her kids to avoid (which she subsequently fenced off).
- The issue of litter was brought up but discarded as an issue with the residents, “There’s a trash bin right there.”
- A lot of details such as material, ground type, and distance between steps on the slide were addressed by the participant.

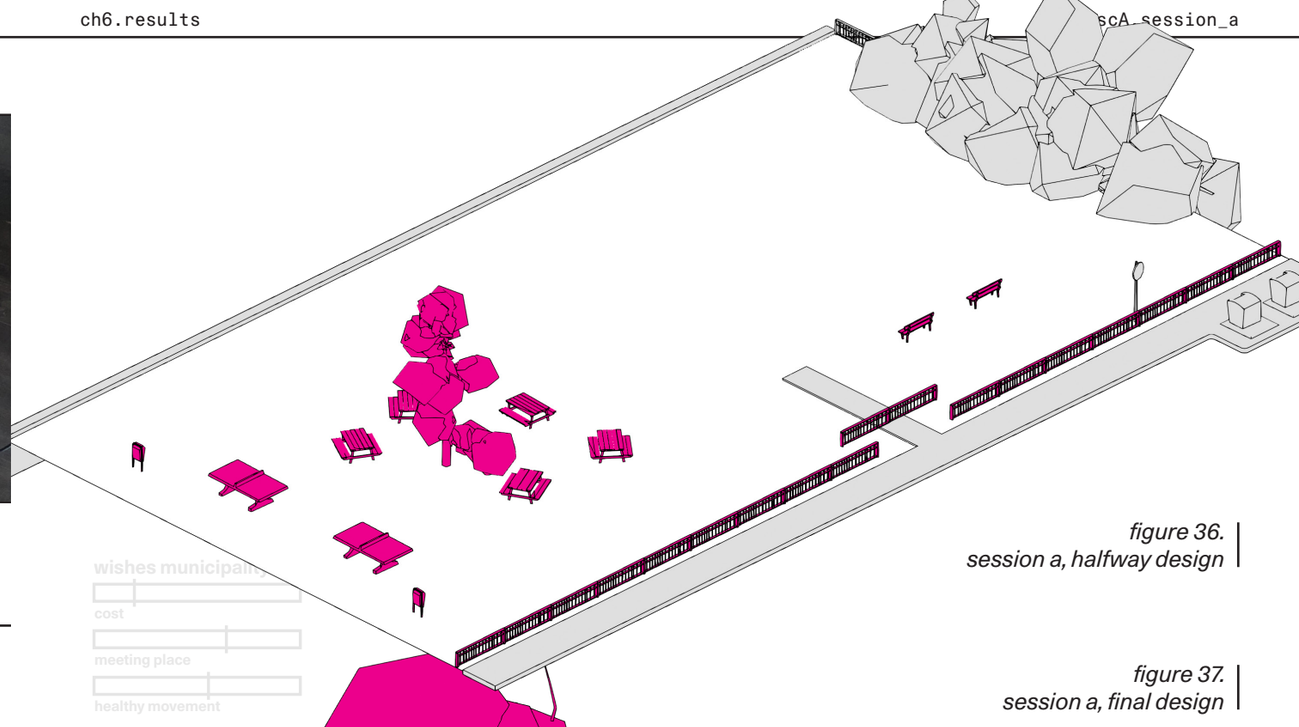


figure 36.
session a, halfway design

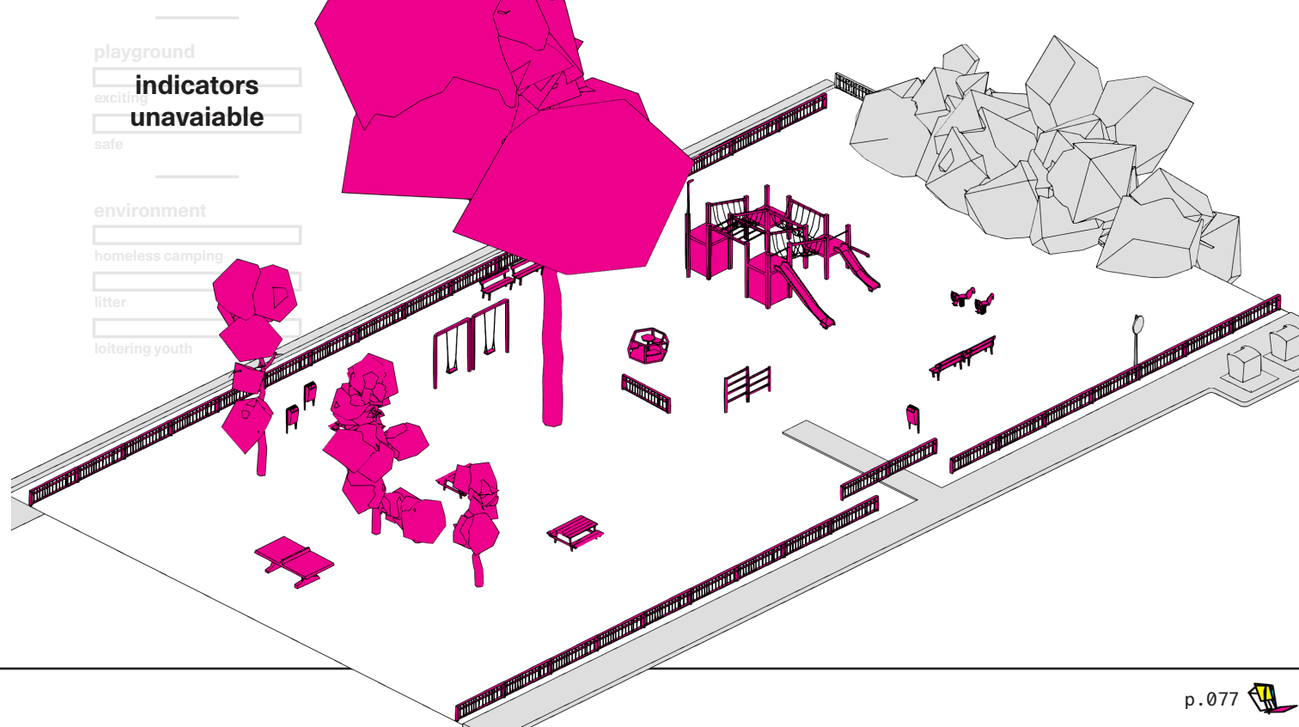


figure 37.
session a, final design

figure 38.
photo from session b

section 6.B: session b

Participants for this session were recruited on the spot when the intended participants did not come. One did not speak Dutch so another participant had to interpret for them, they are only quoted through the other participant's interpretation, not directly.

OBSERVATIONS

- Participants were initially enamoured with the interaction and building options, responding to many with "oh, how cute!" or "super fun!"
- They tried out different lay-outs for a social space with benches and trees, inspired by the shadow cast by a tree in the viewer.
- They suggested a vegetable garden and skating rig which are not in the model, but let go of the idea.
- They were confused and suspicious when the model told them a trash bin cannot be placed due to negative consequences, but obeyed.
- Predictions regarding municipality wishes and another pop-up made sense to them and they followed along, trying to make the playground cheaper.
- Predictions of safety were low and loitering youth were high. They accepted the predictions and came up with their own reasons for why they made sense, but they did not see these as negative consequences and kept the design as is.
- One participant was unconvinced by predictions for homeless people camping, but another came up with an explanation. They did not try to fix it.
- When presented with high litter they placed more trash bins until it went down.

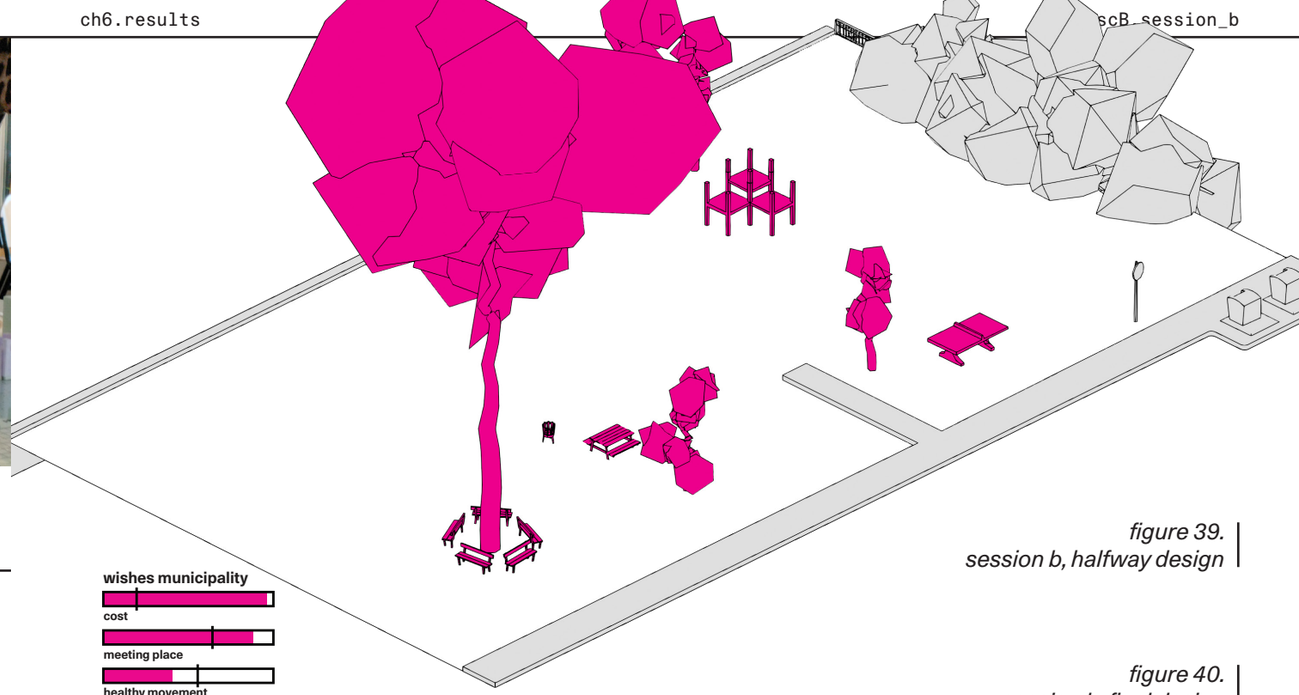


figure 39.
session b, halfway design

figure 40.
session b, final design

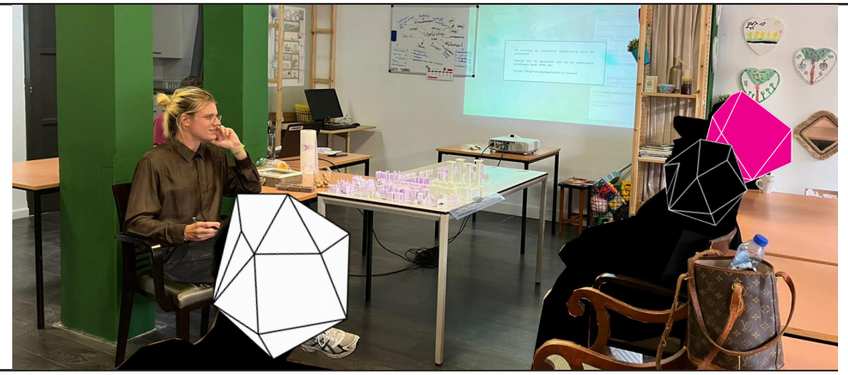


figure 41.
photo from session c

section 6.C: session c

This session was conducted under relative time pressure since some of the participants had to make another appointment.

OBSERVATIONS

- Axo and Bathy had stronger Dutch language skills than the other participants and dominated much of the session:
  - Axo was a younger man who had a less personal interest in the design and would usually move the session forward by responding to feedback from the prototype and objects put down by other participants.
  - Baty was a mother with strong opinions. Her ideas were usually executed and she effectively shot down other participants' suggestions as it was difficult for them to argue with her.
  - Other participants would sometimes put pieces on the map without discussing it with the group.
- Axo tried placing and removing a piece to test the system.
- Bathy built a high fence on the street side without discussion.
- Axo emphasised the importance of trash bins and placed some.
- All participants put down different pieces of playground equipment, some of which were impossible on their own such as a floating bridge connecting nothing or a slide without a ladder.
- Axo tried to fix some of these loose ends by connecting them or adding new pieces.
- Everyone other than Bathy wanted more trees but they did not start a discussion about the issue and moved on.
- Axo paid attention to the predictions and made adjustments to account for most of them (meeting place, loitering youth, homeless).
- The other participants ignored all indicators until told that the high cost might make it impossible to execute, in response to this they made the fence lower (cost was unaffected) before agreeing to submit.

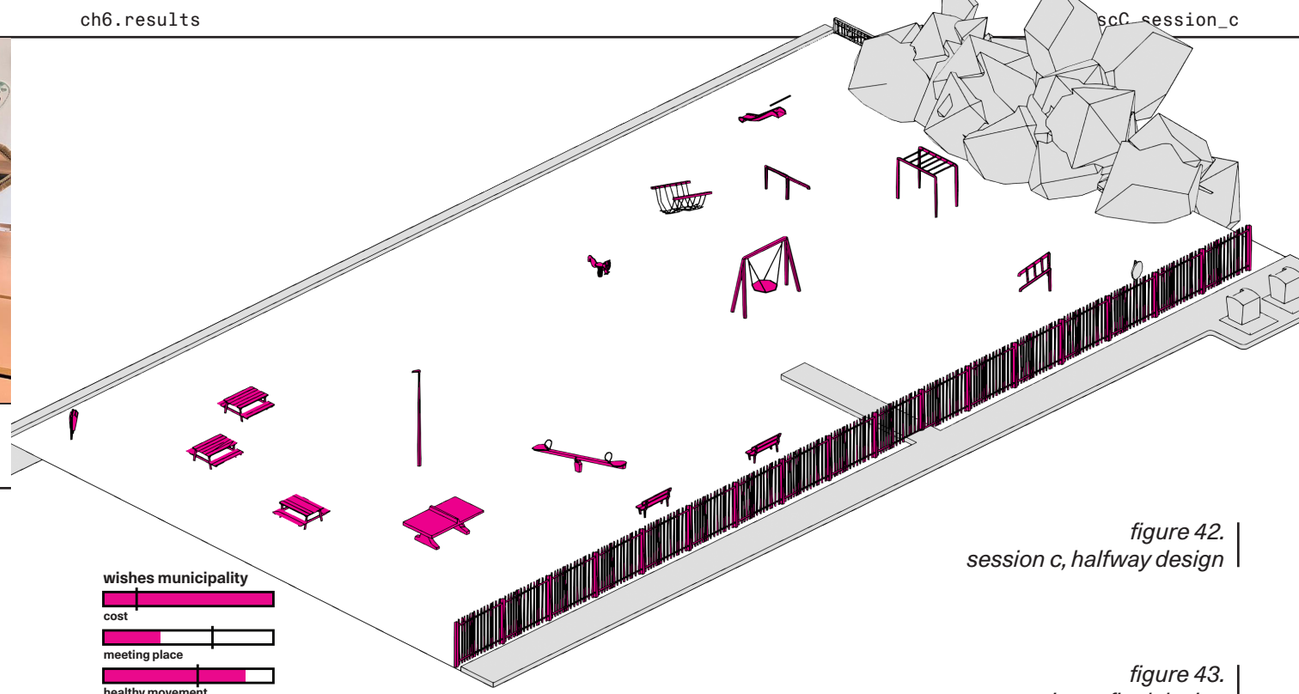


figure 42.
session c, halfway design

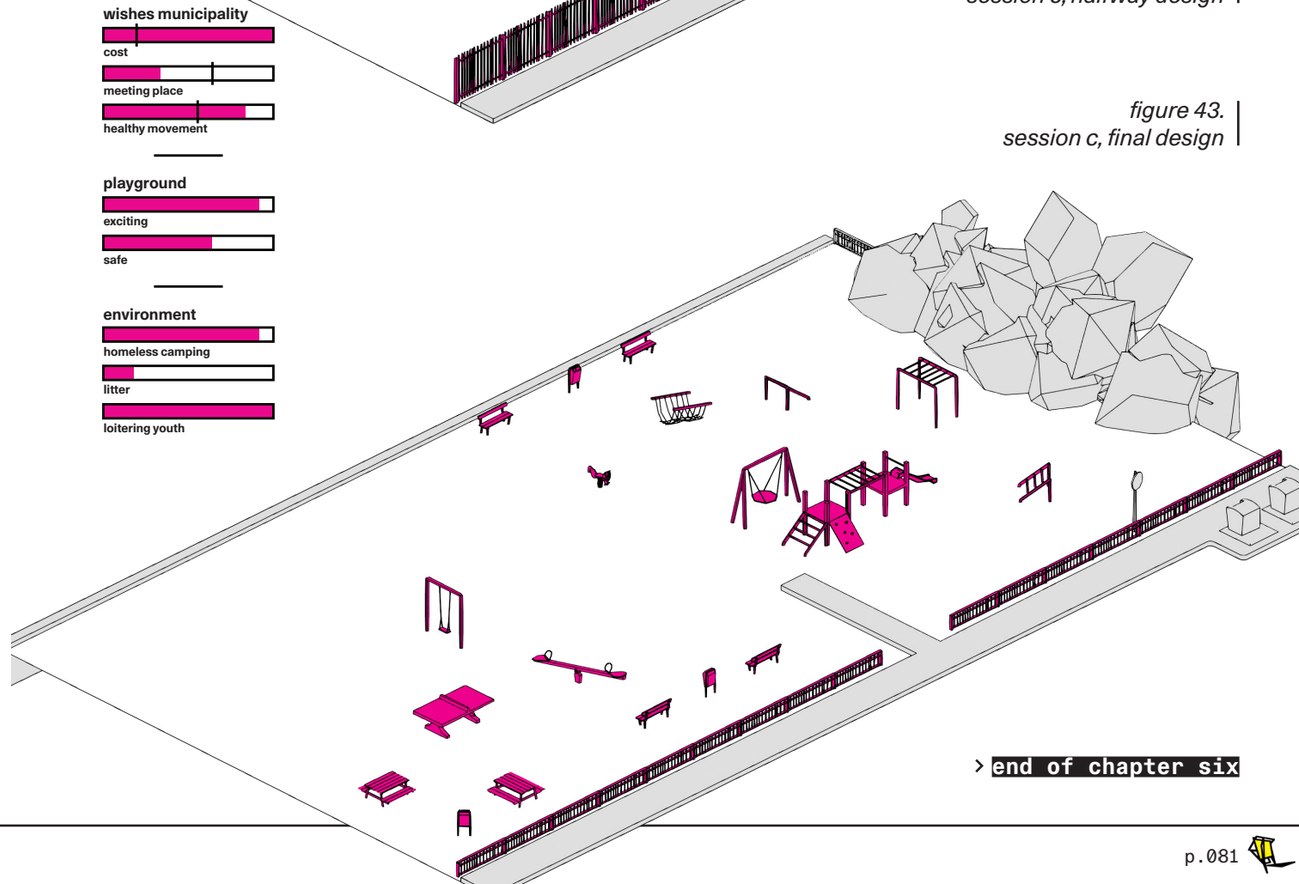
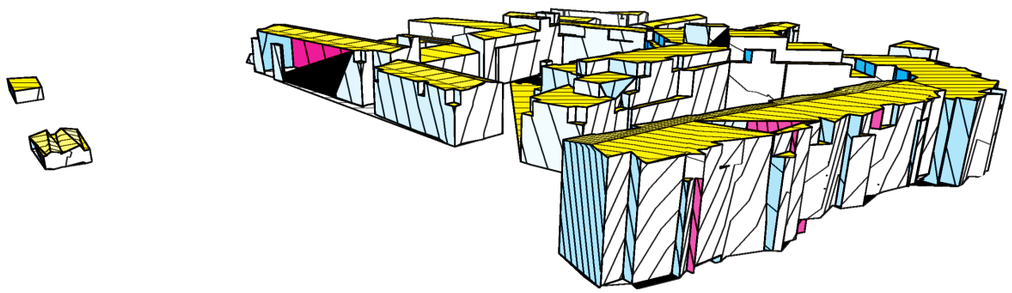


figure 43.
session c, final design

› end of chapter six



Seventh chapter;
Synthesis

This chapter starts by explaining how I conducted my analysis, using my chosen analytical method, thematic analysis, and why it is suited to answering my research question. This resulted in five themes that I discuss in order, providing a description as well as evidence from the observation logs and interview transcripts, followed by a discussion of the implications in relation to the literature. This is used to answer the research questions in the next chapter.

chapter sections

section 7.1: analysis

To generate answers from my collected data I used the method of thematic analysis as described by Braun and Clarke (2006). Thematic analysis provides a structured approach to qualitative research that lets the researcher make sense of their dataset by identifying, organising and investigating the patterns of meaning, or themes, that appear across it, to find and make sense of recurring meanings and experiences. The main advantages of thematic analysis over other qualitative methods of analysis, accessibility and flexibility (Braun & Clarke, 2006) mean it lends itself well to this research: as I am inexperienced with qualitative academic research a less accessible method may prove too complex to execute properly, and since I am drawing upon a mixed dataset, consisting of full interview transcripts and summarised observation logs, the flexibility of thematic analysis makes it possible to identify unified patterns of meaning across these sources.

While transcribing the interviews and supplementing observations from the audio recordings, I took a series of notes. I then started my proper analysis by conducting one round of inductive coding of the interviews, methodically going over the transcripts and generating an extensive set of codes reflective of the sentiments described by citizens during the interviews. I then clustered these codes into a first thematic map describing a preliminary set of themes. The reason I started with inductive analysis was to create an initial set of codes that were as little as possible limited or influenced by literature and my own observations, to most accurately reflect citizens' opinions about urban digital twins and participation, and thus help answer my first research question, how do citizens think urban digital twins should be used in participation?

My next round of analysis was more deductive, and concerned the observation logs. I first returned to my literature review and translated the findings from literature to codes to inform my analysis. I then went through the observation logs and labelled these, using my existing set of codes as well as generating original ones based on events observed during the enactments that did not return in the interviews and were not reflected in the literature. With this large set of codes I finally returned to my interview transcripts and coded these a final time, searching for statements to further contextualise the findings from the literature and analysis of the observations.

Finally, I clustered the final set of codes and examined the relationships between them to arrive at five final themes, which I describe in the following section.

section 7.2: themes

The following section is structured as follows: each theme is presented in order, for each theme, a description is presented and it is explained how the theme derived from the interviews and enactments. Finally these findings are discussed in relation to the literature before moving on to the next theme.

The identified themes can be grouped into two categories, the first one, comprising themes one, two and three, deals mostly with power dynamics between participants, the developer and the digital twin, while the second, containing themes four and five, is concerned with how the design of the interaction impacts the outcome of the participatory process.

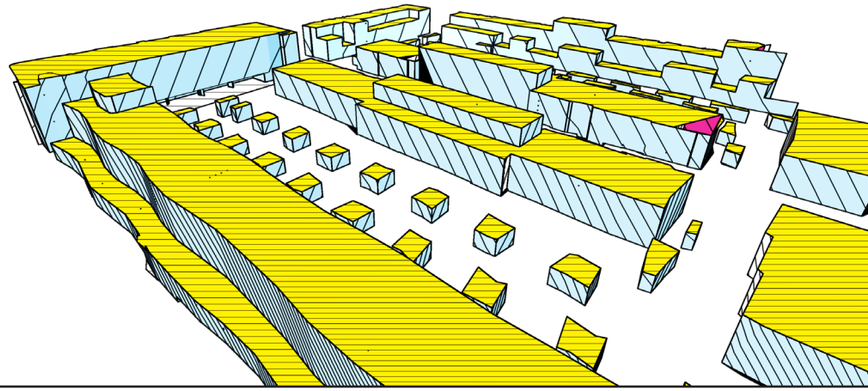
- *i. 3D Chocolate Factory*
  The first theme concerns the general feelings of enthusiasm and excitement expressed during the interviews and enactments, and the implications of this for the participatory process.

- *ii. Tour guide synchronicity*
  This theme is about the power dynamics present during a session: specifically the way in which one party may end up leading the discussion towards certain topics or conclusions, as well as how this leading may otherwise happen in correspondence participation.

- *iii. Accessible scaffolding*
  This theme involves discussions of the inclusivity of urban digital twins for participation and draws upon the previous themes.

- *iv. Calibrating the control panel*
  This theme discusses the design of the input citizens are able to give through urban digital twins. This primarily concerns two conflicting sentiments citizens expressed: on the one hand asking for more detailed design tools while at the same time wanting to leave the details to professionals.

- *v. Clockwork City*
  The final theme discusses the ways in which participants responded to the simulation aspect of the prototype and how they incorporated the metrics into their design decisions.



i.3D CHOCOLATE FACTORY

The first theme concerns the general feelings of enthusiasm and excitement expressed during the interviews and enactments, and the implications of this for the participatory process.

Throughout the interviews, all participants indicated that they enjoyed their interaction in the enactment: “Yes, it’s really fun. If I can do it like this I become happy.” (Bathy.C), and that being able to provide input through a similar tool in real life would be highly valuable, with one participant stating, “I do think the system is very valuable.” (Hypso.A) and another, “I’m a big proponent of this” (Azi.B). While these were comments made with regard to the system as a whole, they seemed to be more aimed at the building and visualisation components, since many of the participants largely ignored the simulation and prediction during the enactment.

Some participants did address the predictions specifically, thinking they were valuable in making more informed decisions, “It gives a certain impression of what it, like, could look like in the end,” (Axo.C) and creating understanding, “You see, what’s special [...] is that the analysis that’s being made here, gives an explanation why certain things don’t end up being executed” (Azi.B). Temporal control over the simulation “Maybe how it looks during day and night? Yeah, that you turn the lighting on and also see, hey, are all the homeless people going to sit under here” (Hypso.A).

This general excitement could also be observed during the enactments, one observation that was shared among all participants, residents as well as non-residents, was that they enthusiastically experimented with the space, adding new objects and looking at them from different angles before moving them around. This can be seen both in how they described their actions, “Shall we put down some more of those fun little concrete benches?” (Meri.B) and in their designs: figure 44 shows how residents filled the space with objects and continued adding more elements as the session went on.

These designs also show how the final result may not clearly communicate the focus of the participants: during both sessions A and C the residents’ highest priority was safety, which they expressed in the design by building fences and by omitting lights, as these were thought to attract unsavoury types at night and make the playground less safe. The fences are quite salient, and from looking at the design a developer could easily deduce their purpose and the underlying need they are meant to address. The values and discussion that led to the exclusion of lights, on the other hand, would be completely invisible if only the final design was shared with a developer.

i.DISCUSSION

Greater enthusiasm during the participation is consistent with the findings of Dembski et al. (2020), who described that participants were more interested and entertained. However, beyond an opportunity to keep people engaged for a deeper conversation, this also presents a risk for a session to lose focus: in both sessions A and C, residents kept adding different objects to the map until the end, rather than focusing on what was most important to them. Creating bloated designs can set unrealistic expectations for the final execution of a project, and participants may be disappointed to find only a small part of their ambitious plans executed, more so when this was the part they cared least about. This risk is especially high in correspondence participation: with how difficult the original needs are to read from the final design, a decision based on the data provided may very well turn out worse for residents than if they were just asked what they find most important.

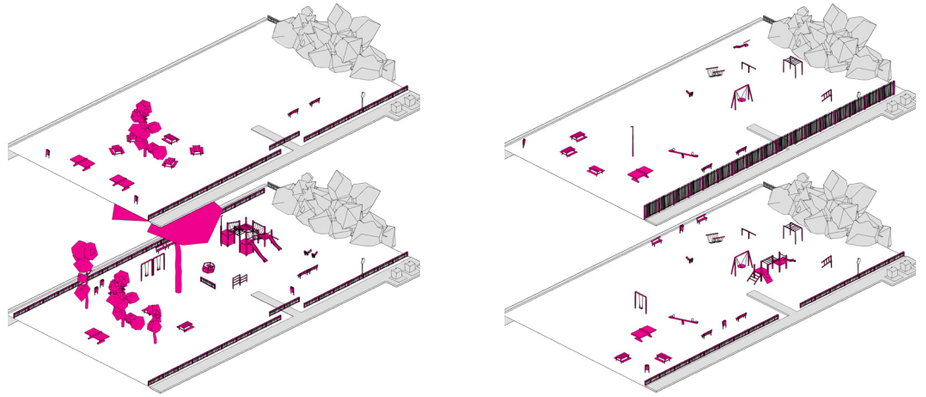


figure 44. sessions A (left) and C (right), halfway and final points (miniature)

Previous evidence suggests focus groups using computer models can have a tendency to get stuck on specific issues or otherwise stray out of scope (Dahinden et al., 2003) and it is important to be aware of the mechanisms by which this might happen in urban digital twins. While making a lot of interventions can be beneficial in a group session with experts as it means more topics will be discussed, it does not guarantee these will actually be of high importance to participants: certain elements, may be interacted more with for their attractiveness, salience, or other qualities that give no guarantee of their importance to participants, and cause more important insights or discussions to be lost. As an example, sessions A and C spent a great deal of time assembling a structure with the modular playground equipment, which participants of both sessions later indicated was of little importance to them to specify: “...what kind of equipment they put down, I don’t care” (Hypso.A).

ii.TOUR GUIDE SYNCHRONICITY

This theme is about the power dynamics present during a session: specifically the way in which one party may end up leading the discussion towards certain topics or conclusions, it also includes discussions of correspondence participation because of their suggested value to circumvent the negative power dynamics of a physical session.

The topic of power balance was hardly discussed during the interviews, but was very noticeable during the enactments, pointing to a high risk of power imbalance during sessions. While many factors can influence this balance (e.g. authority, expertise, race, gender), in the enactments the determining factors were language proficiency and expressiveness: during session B the non-Dutch speaker could follow what was happening, but hardly got involved with the design. She rarely tried to get involved but was asked for input by another participant at times. During session C there were many more participants with varying levels of Dutch, and the session was also dominated by the participants who were most fluent in Dutch. Moreover, one of them (Bathy) was more vocal and effectively pushed her ideas through while shooting down those of other participants:

Choro: ”This one, too.” (putting down a large tree)
Researcher: “A large tree?”
Bathy: “No, that’s not necessary, a large tree”
Researcher: “You do not need any new trees?”
Ekis: “Yes, trees... yes, trees.”
Researcher: “More trees?”
Ekis: “Yes, in the courtyard.”
Bathy: “No. We have enough trees in the courtyard.”
(No one else speaks up)

Other participants still tried to make interventions after this, often by silently placing down elements which resulted in confusing and sometimes impossible constructions (figure 45).

There were also discussions of whether using a similar concept online (correspondence participation) would be preferable. One participant would prefer the convenience of giving their input online: “She says, it’s too much work having to go somewhere, having to fill something in, so I just want to–from my computer...” (Azi, interpreting for Zeni.B). Most however valued doing a physical session, even claiming the presence of a developer as a necessity: “So the municipality or the developer... you want those people there at that moment, because then it’s a collaborative project. [...] Conducting a tool is different from having a person there. I feel heard as a citizen because you’re sitting there writing something” (Azi.B).

ch7.synthesis sc2.themes

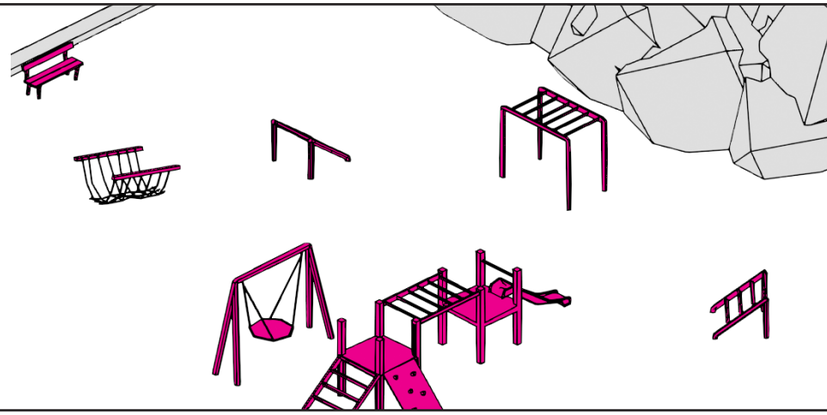


figure 45.
disconnected elements, detail from fig. 43

ii.DISCUSSION

A vocal minority dominating group discussions is a common problem in public participation (Carver et al., 2001), and consistent with previous studies on charrette-type workshops (Howard & Somerville, 2013). The enactments provided no evidence that urban digital twins by themselves will help overcome this, however the tools still provided overpowered participants with an avenue to express themselves, which through a moderator or different interaction design may be capitalised on in future implementations.

Previous studies have suggested the potential for urban digital twins to instead be used in correspondence participation (White et al., 2021; Schrotter & Hürzeler, 2020). An issue with this format is the lack of guarantee the participant’s input represents their own, informed conclusion (Gordon et al., 2014). While not the focus of this research, most participants that commented on it did not express confidence that the tool would be well-suited to such an asynchronous form of participation, as they deemed the human facilitator too important in keeping participants informed and engaged.

iii.ACCESSIBLE SCAFFOLDING

This theme involves discussions of the inclusivity of urban digital twins for participation and draws upon the previous themes.

During interviews participants indicated the visualisation made the process more accessible than a traditional process with paper maps by making it easier for them to communicate their thoughts and ideas, “It’s easier to explain something through [the tool] building it, instead of having to explain like, I want this and this” (Hypso.A). Some also thought it aided inclusivity by making it easier to follow for people less fluent in the language, “I’m very glad that it’s visual. Lesser speakers, foreign speakers, often can’t follow long texts [...] You could even do this with children” (Azi.B).

The enactments painted a more complex picture: as discussed in the previous theme, it was difficult for participants with lower language proficiency to make an impact on the process.

iii.DISCUSSION

The supposed intuitiveness of visualisations has been proposed in the past as a way in which urban digital twins can help make processes of participation more inclusive, with traditional methods failing to reach time-poor, younger and culturally diverse citizens (Fredericks et al., 2018). A previous urban digital twin study claimed that it was easy and intuitive to use for lay persons (Schrotter & Hürzeler, 2020). While this is supported by my findings, this study importantly also shows that there are large social obstacles to inclusivity that may prove more difficult to handle with digital twins. These obstacles may be alleviated by correspondence participation, as suggested in several case studies (White et al., 2021; Schrotter & Hürzeler, 2020), but this comes with its own set of difficulties to realising inclusive participation, such as accessibility to less tech-savvy citizens, as seen in the digital twin of Rotterdam (De Jaeger, 2023), and runs the risk of reaching only a small subgroup of people primarily consisting of white, middle-class men (Touchton et al., 2019).
So, in order for urban digital twins to contribute to more inclusive participation, future implementations will have to address these social obstacles to inclusivity in their design.

Lastly, there were no discussions questioning the inclusivity of the data in the model. Participants did not ask what kind of data would be used to fuel the predictions, or whether they themselves were represented in the model. This could be interpreted as my failing to produce a prototype which clearly elicits these questions, but also indicates that these are not necessarily obvious questions for citizens to ask.

iv.CALIBRATING THE CONTROL PANEL

This theme discusses the design of the input citizens are able to give through urban digital twins, primarily, this concerns two conflicting sentiments citizens expressed: on the one hand asking for more detailed design tools and putting a lot of thought into the designs they made, while at the same time saying they trust that professionals from the municipality would be better suited to designing the playground as long as their core values (e.g. safety) were communicated well.

In interviews participants indicated they would have liked more input options, desiring “blank” objects they can assign meaning themselves and the ability to go into more detail with the design, saying, “I miss colour. I can’t choose the colour... and I miss light! [...] I miss other items” (Azi.B). Some, however, were also critical that too many tools might make it overwhelming and ineffective: “If you give them too many tools, then people can also get confused, then they don’t know anymore, then they get stressed out” (Meri.B).
During the enactments the value of having many details to discuss was also shown: as more objects and predictions were brought forward, participants came up with arguments for and against certain design decisions and provided many valuable insights about the neighbourhood and the playground, as illustrated by the following conversation during session C when discussing the placement of lamps:

Axo: “Then lights are important, I think”
Bathy: “Yes of course... but kids never go play in the evening, just people doing drugs [...] Let’s keep it dark. Mothers take their kids home when it gets dark.”
(Other mothers nod in agreement)

The set of inputs given to participants does dictate the topics of discussion and the perceived options: only once during session A, twice during session B and not at all in session C did participants choose or bring up something that was not included in the set they were presented with. Choices did not necessarily have to be “makeable” in the tool to be discussed however: most pieces of equipment had a metallic texture which, when noticed by a participant, led to discussion of the material and heat at the playground during summer.

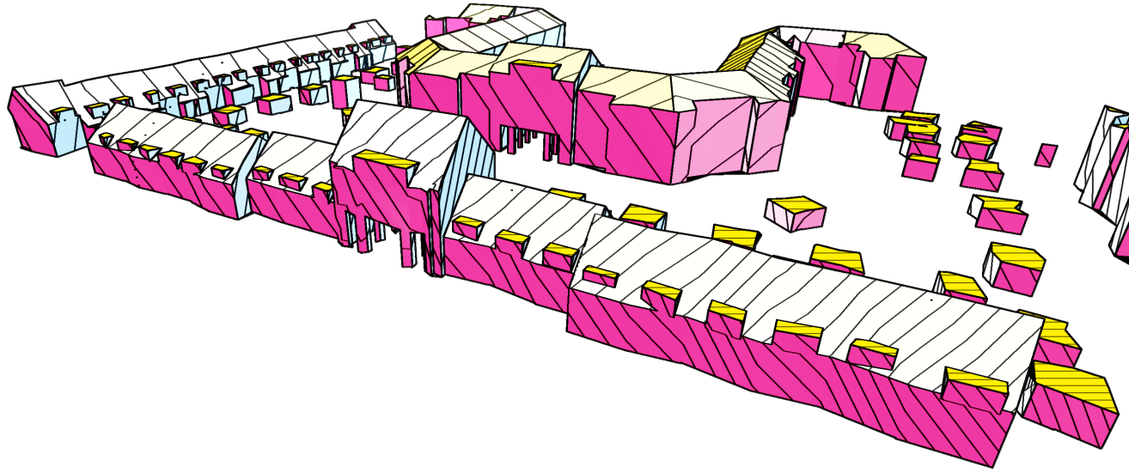
(continues on next page)

iv.CALIBRATING THE CONTROL PANEL (continuation)

Despite their enthusiasm for design and discussing details, when asked, most participants still said that, as long as their general needs were clear, they would rather leave the design to experts, saying things like, “To be honest, I think that professionals could do better than–” (Axo.C). This sentiment was perhaps best captured by participant Hypso (session A): “As a mother, I just want to sit there with peace of mind, [..] and what kind of image the municipality has with that, what kind of equipment they put down, I don’t care.” This was not an unconditional expression of trust, however, as participants also emphasised the importance and value of a later follow-up to critically assess the municipality’s design before it is executed. One stating, “You want a feedback moment, you want a reaction,” (Meri.B) and another, “Yeah, on that square let them... ‘Dear residents, this is what it became in the end, [...]’ And then if there’s really something, like iron, that you can just really come with strong arguments, “We don’t want metal in the playground because this, this and this,” that you can still say that, that they can still think about that for a minute“ (Hypso.A). So while participants expressed satisfaction with communicating their most important needs and leaving the design of the specifics to the professionals, they did not necessarily trust the municipality to follow up on their needs correctly.

At the same time, they still thought using the urban digital twin for co-creative participation was useful. One participant, even though she thought the municipality should tackle the specifics of design, was convinced that building together using a tool like the one used in the interaction was a good way to get policy makers to listen, saying, “Yes... is better to do [participation] like this, then you listen,” (Bathy.C) and another also spoke about the value of this kind of input: “I think there’s something to it, that... that the neighbourhood shows roughly what they want and that they [the municipality] nuance it a bit. Their own design” (Axo.C).

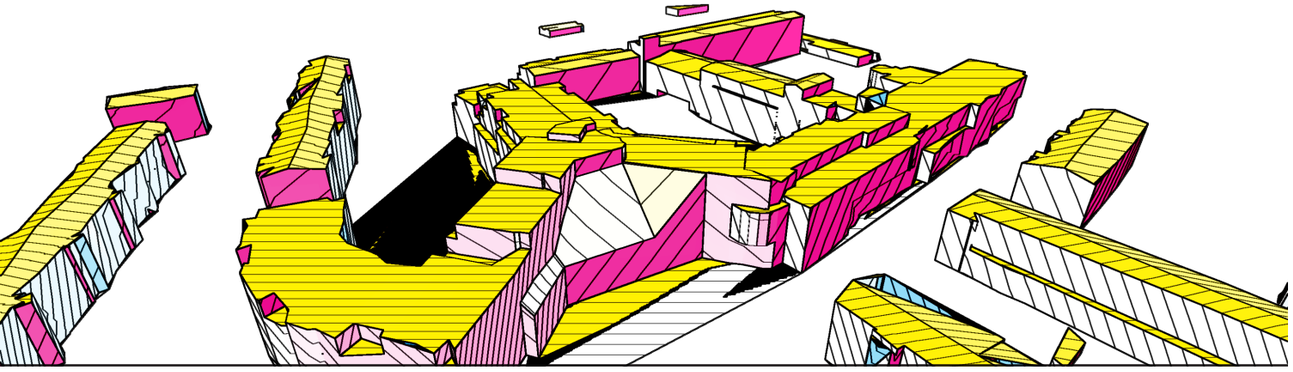
In this light, one of the possibilities some participants were excited about was using the technology to showcase how elements from citizens’ designs were used in the final design. This can place a burden of proof on planners to show they actively engaged with the ideas brought forth by citizens as both the input and the output are there for everyone to see.



iv.DISCUSSION

The conflict between wanting detailed inputs and wanting to leave the details to experts can be thought of as in fact not a conflict at all and instead an interesting opportunity. If we return to Innes and Booher’s (2004) goals of participation, we find incorporating citizens’ local knowledge, an important goal to which the citizens’ detailed discussions provide a productive platform, provided these discussions are either with developers, or their insights are effectively communicated, the latter presenting a serious challenge in itself. The findings also show that citizens’ insight can be accessed without asking for input on every topic but rather by making them concrete for discussion through the design of the medium, as illustrated by the discussion of heat and material.

The expressed need for a feedback moment is consistent with the need for transparency in decision-making identified by De Jaeger (2023), as citizens want to see what is done with their input. The proposed use of urban digital twins to show the link between citizens’ inputs and a final design could help amend issues of transparency like those of the Rotterdam pilot (De Jaeger, 2023). Furthermore, it expresses a need for more decision-making power in the end stage of the process, this is in line with the findings of Jansma (2022), who identified exertion of influence on the decision-making process as the most important determinant for citizens to participate using urban digital twins.



v.CLOCKWORK CITY

The final theme discusses the ways in which participants responded to the simulation aspect of the prototype and how they incorporated the metrics into their design decisions.

The model presented people with metrics about the future impact of their design, some of which were based entirely on a spectrum of random numbers. Despite this, they were eager to accept them and made up their own explanations for why their design led to that outcome, for example saying, “Well yeah, you know there’s going to be loitering youth* on those climbing walls, right?” (Azi.B). Only once was someone confused enough about a prediction to ask for an explanation. A beautiful and unexpected consequence of this is that these explanations were often quite logical and actually enriched the discussion, as they still provided insight into certain mechanisms at work in the neighbourhood even if their end conclusion was based on a random number. When questioned who benefits most from the model's predictions, certain participants also saw the danger of this:

**Translation note: in Dutch the word “hangjongeren” is commonly used to refer in a derogatory way to adolescents hanging around public spaces. It is here translated with loitering youth which is the closest analog but carries different connotations.*

Azi: “The municipality [benefits most], understanding. The developer. Because once you show this as a fact, a resident will think, ‘Oh yeah, that’s why this can’t happen.’ While that might not be the case, but you go... you take it for granted.”
Researcher: “So you think it could serve to let things be accepted sooner...”
Azi: “Yes.”
Researcher: “...and to go along with things?”
Azi: “Yes, it’s a bit manipulative. Yeah, right. ‘Very expensive!’ And in reality it is expensive... but still.”
Researcher: “And you saw this in your own behaviour as well?”
Azi: “We adjusted ourselves. (We pasten ons aan.)”
Meri: “Yes... you do adjust yourself."

All participants paid attention to cost and at some point during the session made attempts to adjust their design to the budget by removing objects or replacing them with cheaper alternatives, when this failed (as it did by design) they would move on. Responses to the predictions were more varied: some participants paid no attention to any predictions, and some of the predictions, such as “exciting” were too intangible for people to properly respond to, however, when people were given an uncontroversial indicator and an obvious way to affect it, they were inclined to treat it as a puzzle to solve, and to respond positively when their solution works, “Look, we’re solving litter!” (Meri.B). This is illustrated by the example of litter: both session B and session C placed many trash bins to counter litter, and when this turned out to work they reported a sense of ownership and pride: “See, litter: you put down a few trash bins and then the litter disappears. So that interactivity... I got the sense that I had some ownership. To... yeah, to solve it?” (Azi.B).

Even if they believed the predictions they were given, participants did not necessarily try to “solve them” in the same way, as can be seen in the example of the “loitering youth” indicator: the group in session C lowered their fence in an attempt to cut costs and saw the indicator sharply increase, they had an intuitively negative response to this and wanted to revert the situation, saying, “I think it’s worse, loitering youth increased, homeless people camping used to be zero and now it’s almost full, so we did something wrong there” (Axo.C). In session B the value was already high by the time it was revealed, which made sense to the participants, unlike group C however, they welcomed them and proposed doing community projects with them instead: “But at the municipality they don’t like that, because they see loitering youth as a problem. But that doesn’t have to be a problem of course, you can do very fun projects with them, with those youths. We were all kids once, we are all a bunch of loitering youths” (Meri.B).

(discussion on next page)

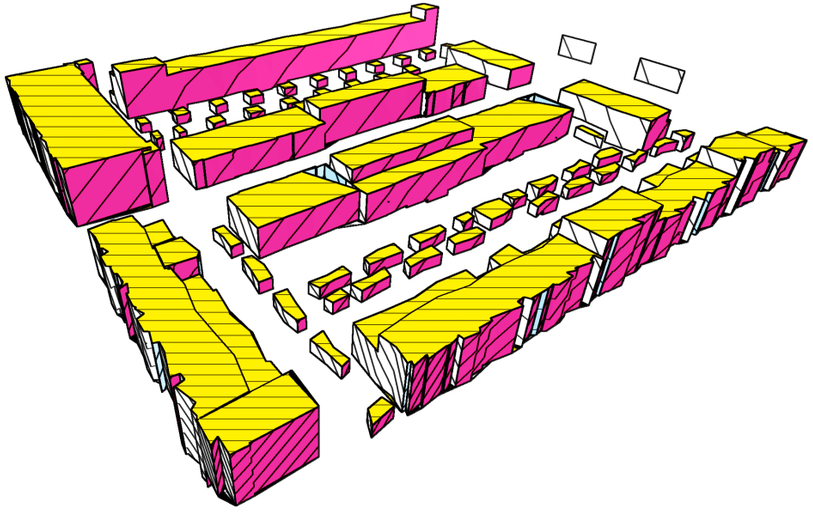
v.DISCUSSION

On the one hand, the greater understanding of the constraints and trade-offs involved in a project that was afforded to participants might help increase trust and decrease polarisation between citizens and the municipality, which presents a common issue with methods of public engagement (Zhang & Fung, 2013). Additionally, presenting residents with the problems and dilemmas plaguing the design process creates an opportunity to valorise citizens' creativity, pushing them to come up with solutions based on their local expertise.

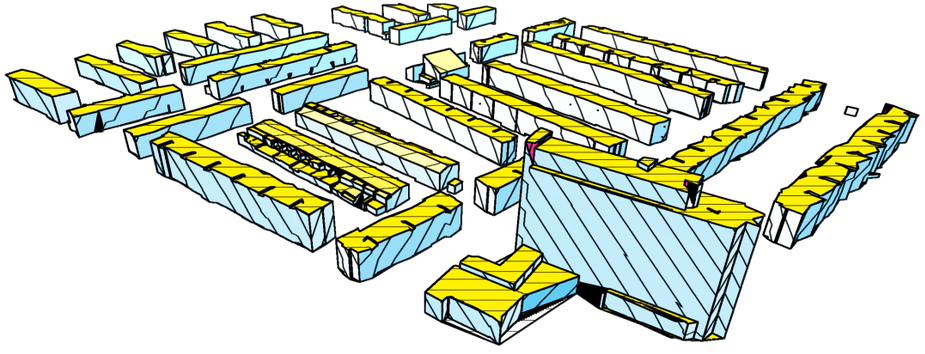
The danger is obvious though: models are always simplifications of reality, and a digital twin of an ecosystem as complex as a city can never be considered realistic (Batty, 2018; Cureton & Dunn, 2020; Nochta et al., 2020). Furthermore, they are a translation of reality made by humans which is inherently non-neutral (Korenhof et al., 2021), meaning both the assumptions of the developer and biases contained in the data used to develop it are embedded in the digital twin, and by extension the predictions it makes. When you assume these to be a true representation of the future, at best, it is easy to become compliant with whatever policy looks best through the lens of the model. At worst, project developers can calibrate the model to better suit their proposals. This is similar to the risk observed in participatory processes using GIS, whose high-fidelity visualisations made it difficult for participants to argue against developers (Obermeyer, 1998) and further emphasises the need for this issue to be addressed in the design of urban digital twins for participation.

Furthermore, setting clear win and loss conditions is an oversimplification of reality, which leads to simplified solutions. The model presents wicked problems as tame, while the problem is still just as wicked, it just tries to tackle it with tame solutions. When citizens adapt their design within the application to optimise for a certain parameter, they feel ownership and satisfaction for a solution that, in a way, the model came up with within the constraints set by the project developer, essentially closing the door to more creative solutions and manufacturing a support base for technocratic decisions, that have the appearance of citizens' ideas, which defeats the purpose of doing participation in the first place (Birhane, 2022). Batty (2019) warned about the risk of the inaccuracies embedded in the digital twin becoming reinforced in the physical city as the model is used to inform decision-making, and when urban digital twins are carelessly used in participatory processes this is precisely what happens, but under the veneer of direct democracy.

ch7.synthesis sc2.themes



› This chapter presented the analysis of the results from the three sessions, which resulted in five core themes. The results were discussed in relation to the literature in order to synthesise new insights. The next chapter provides an overview of the most important of these insights in the form of the risks and benefits associated with using urban digital twins for participation, along with a strategy for how to best exploit these benefits and mitigate these risks.



Eigth chapter; *Conclusion*

This chapter looks back at the findings from the synthesis to provide an answer to the research questions, providing a list of risks and benefits to the use of urban digital twins in participation, along with recommendations for how to best respond to these. Finally, a possible design proposal is presented to contextualise the suggestions.

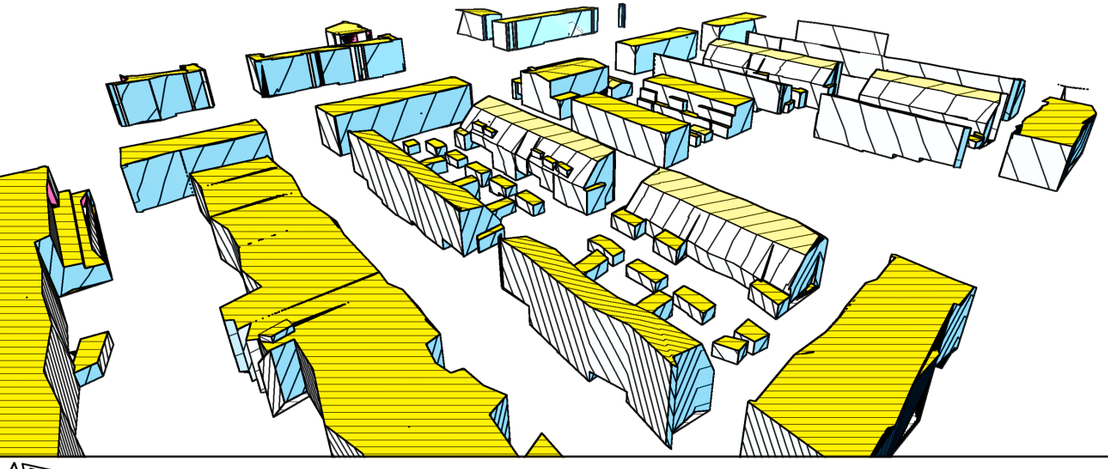
In this study I set out to answer the following research questions by conducting Speculative Enactments (Elsden et al., 2017) with citizens of what a participatory process using an urban digital twin could look like and holding interviews with them about the experience. From these observations and interviews I synthesised various findings which I use here to answer the two research questions of the study, first summarising the opinions citizens gave during the interviews, and then further contextualising them with further findings from my analysis to provide an overview of risks and benefits. This leads to an overall conclusion about how to apply urban digital twins in public participation.

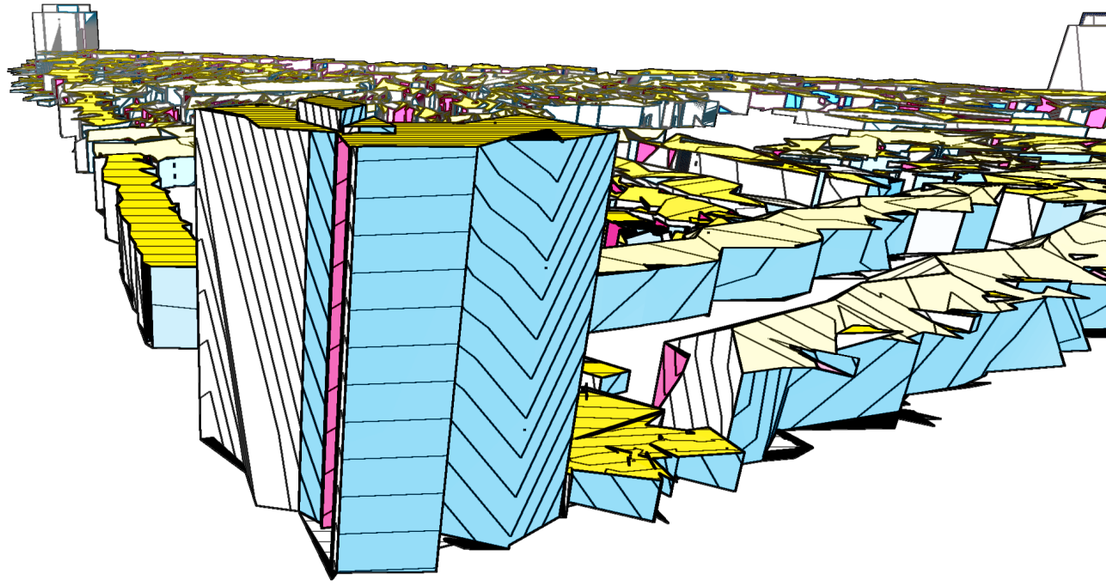
chapter sections

section 8.1: citizens' opinion

RQ1. What do citizens think about using urban digital twins in public participation?

Throughout the interviews, citizens were enthusiastic and optimistic about using 3D building tools with visualisations and the benefit this may bring to participatory processes. They generally preferred physical sessions with experts there, but some were also open to an online, asynchronous process. Some participants thought the visual nature of urban digital twins could make the process accessible to a larger group, including people with lower language proficiency. Citizens indicated desiring more high fidelity tools to express themselves in their designs, but were generally comfortable leaving the detailed design to experts. They also communicated a need to be able to give feedback on the final design before execution and were enthusiastic about the use of the digital twin for this purpose, potentially using it to show what was done with their input. Most participants were receptive to the predictions provided by the digital twin and some found them helpful, while a small group found they were manipulative and could work to stifle discussions.





section 8.2: risks & benefits

RQ2. What are the potential risks and benefits of using urban digital twins in public participation?

Analysis of the interviews and enactment observations in the context of literature on urban digital twins and participation provided a less optimistic image than participants' own words. Table 3 on the next page provides a full list of identified risks and benefits, along with recommendations for how best to exploit the benefits and mitigate the risks.

	benefits	risks	recommendations
1	Visualisation and attractive interaction can keep participants engaged for longer. — Visualisation makes the process easier to follow for participants with lesser language skills.		Emphasise the visual aspect of the interaction, as well as the immediate visual feedback on an action.
2	Presenting residents with the problems and dilemmas plaguing the design process creates an opportunity to valorise citizens' creativity.	When citizens adapt their decisions to optimise the model's parameters, they may feel ownership for choices that the model could have just as well come up with itself, creating a support base for technocratic decisions instead of searching for creative solutions outside the constraints of the model.	Let the model point to issues, but do not let it judge whether a problem has been sufficiently solved or not. Allow the recording of textual inputs that are not limited by a predefined set of "assets", both to prevent participants' inputs from being confined by the digital twin and because mere asset placement information is arguably not as useful as qualitative insights.
3	Urban digital twins can help citizens understand the trade-offs involved in decision-making and therefore decrease polarisation and improve collaboration between citizens and the municipality.	It was difficult for participants to question the biases and limitations of the model. This can be related to the model's black box nature and implied complexity as well as participants' digital literacy. — Participants generally accommodated the model's predictions. This way the decision-making process can reinforce the biases of the model in reality.	Let the model be honest, clear and upfront about its own biases and limitations without requiring participants to understand its inner workings, as well as invite participants to challenge its conclusions based on local expertise.
4	Discussing detailed design decisions can lead to great and unexpected insights surfacing from residents	Design using urban digital twins can lose sight of important insight in favour of details that are attractive or stand out more.	Complexity and detail are revealed gradually, as a result of the participants' own actions rather than a process defined by the developer.
5		This issue of a vocal minority overpowering discussions was not circumvented by urban digital twins.	Integrate a ruleset into the interaction that gives all participants equal ability to direct the conversation.
6	Showing a rich visualisation can surface discussions about design decisions implied in the visualisation (e.g. materials) without adding complexity to the model or the process.		Rather than aiming for a maximum fidelity of inputs that can be processed by the model, show concretely designed objects. If people see something wrong with it they will naturally respond to it in their own words and choice paralysis when giving inputs is mitigated.
7	Urban digital twins can be used to show the link between citizens' inputs and a final design to help increase transparency and bolster the legitimacy of the decisions made.		Implement a data structure that leaves traces of discussions and arguments and therefore lets developers effectively process and refer back to citizens' input.

table 3.
overview of risks, benefits and recommendations

ch8.conclusion sc2.risks&benefits

section 8.3: design recommendations

Many of the presented risks and benefits are interdependent and cannot be understood, let alone solved, in isolation. Focusing solely on one issue may exacerbate another or compromise a benefit, so to give an idea of the kind of risk mitigation strategy that may be applied, I present a rough concept of what an urban digital twin for participation implementation could look like, zooming in on how it addresses the aforementioned risks and benefits. Bear in mind that while this proposal is based on the knowledge I have gained over the course of this research and my prior experience as an interaction designer, it is untested and therefore unready for implementation.

I have tried to design a proposal that is more or less generalisable to both physical and online participation in different contexts, but it is primarily informed by the context in which I conducted my research, physical sessions for the spatial design of a playground in Moerwijk. I thus want to echo Nochta et al. (2021) and emphasise the need for the interaction design of an implementation to reflect the local circumstances.

recommendation one:

Emphasise the visual aspect of the interaction, as well as the immediate visual feedback on an action.

In this regard the speculative prototype was already quite successful, so I propose to keep this as the core of the interaction: a street level visualisation that emphasises immersion, and an intuitive mechanism for participants to make changes and view the space from different angles.

exploited benefit:
Visualisation and attractive interaction can keep participants engaged for longer.
—
Visualisation makes the process easier to follow for participants with lesser language skills.

This keeps participants engaged and allows them to follow what is going on where language may fall short.

mitigated risk:
none

ch8.conclusion sc3.recommendations

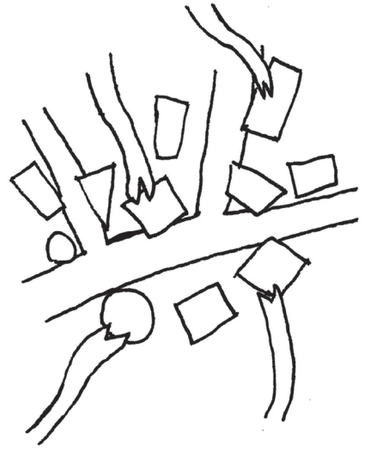


figure 46.
putting it on the map

recommendation two:

Let the model point to issues, but do not let it judge whether a problem has been sufficiently solved or not. Allow the recording of textual inputs that are not limited by a predefined set of "assets".

I propose an alternative form of inputs called patterns, inspired by the pattern language system of Christopher Alexander (1977), which has previously been suggested to lend itself well to use in (digital) participation (Ali et al., 2009). A pattern can be seen as a format for a solution to a problem that exists in a network of other such problems and solutions. In my application of it, a pattern has the following properties: the benefit that it provides and a set of relations to other patterns (figure 47).

A pattern can be a physical object or a less tangible intervention, such as a service or a material to be applied to all objects, and can be chosen from a predefined set or written by participants.

The benefit of the pattern is a collaborative effort between the urban digital twin and the participants: when a pattern is added the digital twin writes the most important arguments for and against its implementation based on the model's predictions, written in natural language. The ball is then passed to the participants who can respond to these benefits and drawbacks either by (1) adding their own benefits (for example if their reason for adding the pattern is not mentioned), or (2) overriding the twin's arguments, editing or deleting one altogether if they have a reason to deem it invalid.

exploited benefit:
Presenting residents with the problems and dilemmas plaguing the design process creates an opportunity to valorise citizens' creativity.

mitigated risk:
When citizens adapt their decisions to optimise the model's parameters, they may feel ownership for choices that the model could have just as well come up with itself, creating a support base for technocratic decisions instead of searching for creative solutions outside the constraints of the model.

Using patterns instead of only assets is much less restrictive to the process, as it invites participants to give more qualitative inputs, explaining the reasoning behind their choices, rather than merely providing a choice and location of assets which is arguably not as useful of an insight to be gained from a participatory process. It also lends itself better to the placement of custom patterns, preventing participants' inputs from being confined by predefined assets that need to be integrated into the model and that it needs to be able to respond to.

The presentation of predictions as contestable benefits and drawbacks still challenges participants to come up with creative solutions to issues identified by the digital twin, but mitigates its technocratic nature by giving participants' the last word to decide whether an intervention is a good idea or not, rather than being subjected to a metric that defines it as good or bad.

ch8.conclusion sc3.recommendations

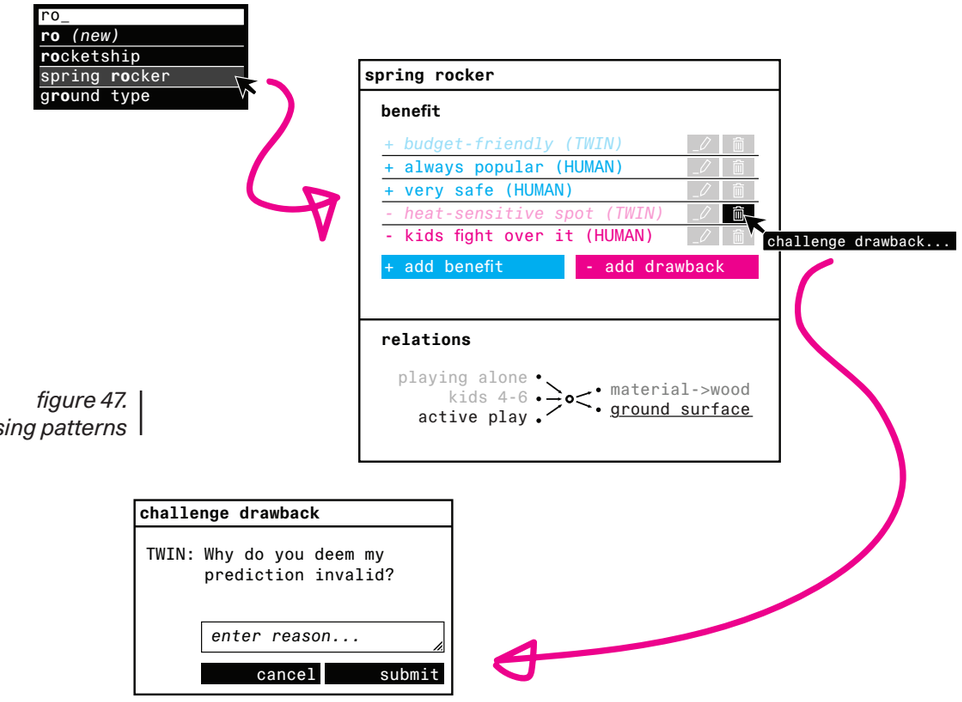


figure 47. using patterns

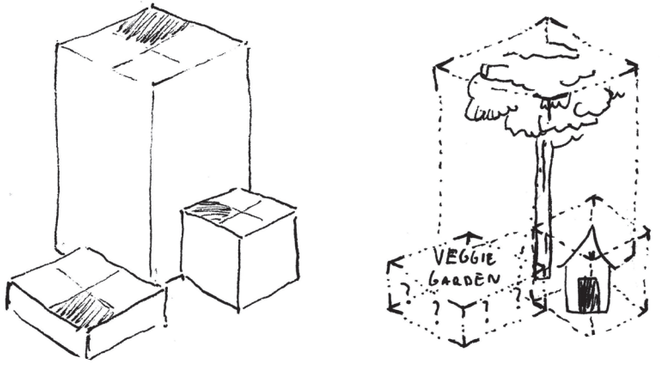


figure 48. physical volumes (left) can refer to both predefined and undefined patterns (right)

recommendation three:

Let the model be honest, clear and upfront about its own biases and limitations without requiring participants to understand its inner workings, as well as invite participants to challenge its conclusions based on local expertise.

Predictions made by the model are not presented as numbers generated by an omniscient algorithm, but as arguments for conjectured benefits and drawbacks communicated in natural language. Recent data-to-text natural language generation models show great promise in combining various kinds of data points into readable sentences (Kale & Ragosti, 2020), but even rule-based translation could serve to help participants understand the predictions given to them by the model and challenge them, turning the twin into a knowledgeable debate partner rather than an oracle. When given the tools to do so, some participants may agree with a presented argument while others may not, potentially leading to more fruitful discussions.

exploited benefit:
Urban digital twins can help citizens understand the trade-offs involved in decision-making and therefore decrease polarisation and improve collaboration between citizens and the municipality.

This can help participants understand the trade-offs that experts are faced with more than when they are simply given numbers without any explanation. Furthermore, if they understand the reasoning this allows them to question the model's conclusions and further enrich it.

mitigated risk:
It was difficult for participants to question the biases and limitations of the model. This can be related to the model's black box nature and implied complexity as well as participants' digital literacy.
—
Participants generally accommodated the model's predictions. This way the decision-making process can reinforce the biases of the model in reality.

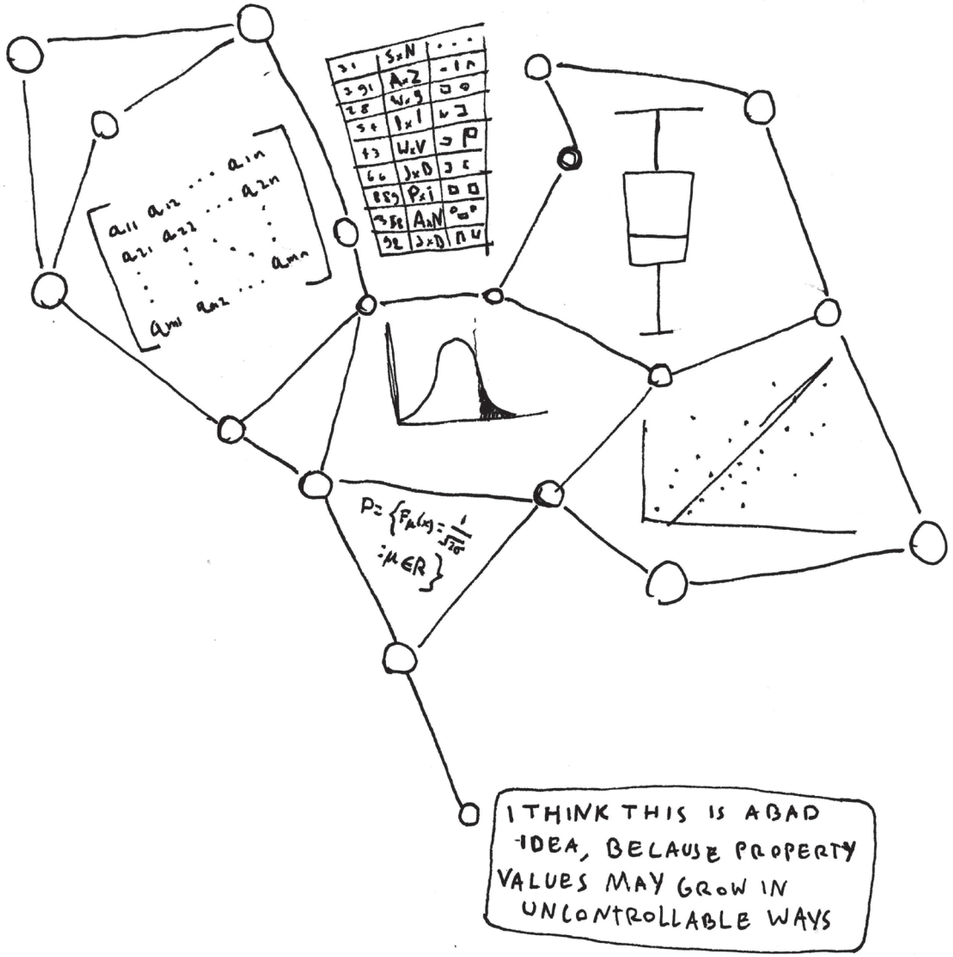


figure 49.
data-to-text

recommendation four:

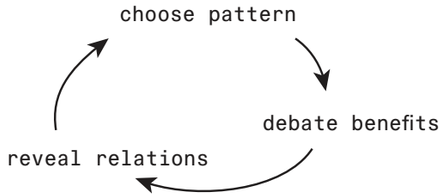
Complexity and detail are revealed gradually, as a result of the participants' own actions rather than a process defined by the developer.

The relations between patterns serve to gradually add complexity over time: not all patterns in the dictionary are immediately presented to the participants, instead when a pattern is added, all the patterns that it has a relation to are revealed (figure 50, the top one with the loops). When participants decide to add something themselves they may also end up adding a pattern that was previously hidden, unlocking the nodes connected to it (figure 51, the bottom one with).

exploited benefit:
Discussing detailed design decisions can lead to great and unexpected insights surfacing from residents.

mitigated risk:
Design using urban digital twins can lose sight of important insight in favour of details that are attractive or stand out more.

By starting with a few high-level patterns such as "active play" or a general layout, participants first focus on the bigger issues before considering smaller details. This method of unveiling also causes the conversation to be guided by the choices of participants rather than a moderator or a predetermined process defined by a developer. Only the details that are relevant to the participants are revealed.



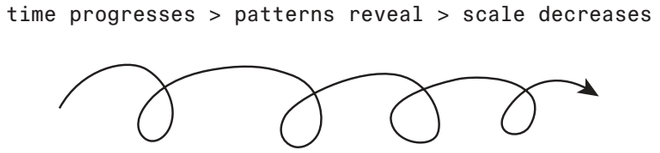
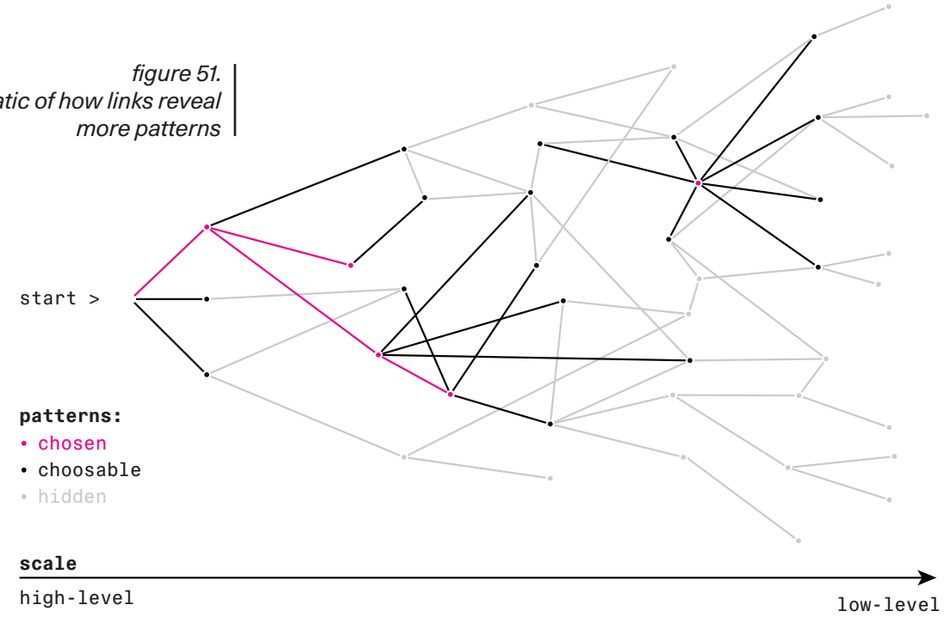


figure 50.
the core interaction loop over time

figure 51.
schematic of how links reveal more patterns



recommendation five:

Integrate a ruleset into the interaction that gives all participants equal ability to direct the conversation.

Participants are in turn given the opportunity to introduce a pattern or respond to an existing one. When they do they are given a short protected time to explain why.

exploited benefit:
none

mitigated risk:
This issue of a vocal minority overpowering discussions was not circumvented by urban digital twins.

In the speculative test design participants that were overpowered in conversation still tried to introduce elements to the scene but were not able to defend their choices in a discussion. This is a difficult problem to overcome through design, but implementing a ruleset that gives each participant protected time to introduce an argument that is important to them can help these to at least be heard and recorded, even if they are later overridden in the discussion.

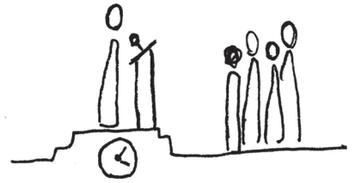


figure 52.
during protected time everyone should listen

recommendation six:
Rather than aiming for a maximum fidelity of inputs that can be processed by the model, show concretely designed objects. If people see something wrong with it they will naturally respond to it in their own words and choice paralysis when giving inputs is mitigated.

There is not a pattern for every conceivable design choice or intervention as there are too many important details to consider, instead they are hinted at in the design of the assets that can be placed. Non-physical patterns should contain a photo or illustration of the situation in which they appear (figure 53). When this leads to ideas or discussion among participants they can record those in the form of benefits or a custom pattern.

exploited benefit:
Showing a rich visualisation can surface discussions about design decisions implied in the visualisation (e.g. materials) without adding complexity to the model or the process.

mitigated risk:
none

Providing visualisations that make a pattern concrete can provoke the participants and lead to important details being explored while sidestepping the time and cost of implementing them all as patterns and the complexity that comes with it which might overwhelm participants.

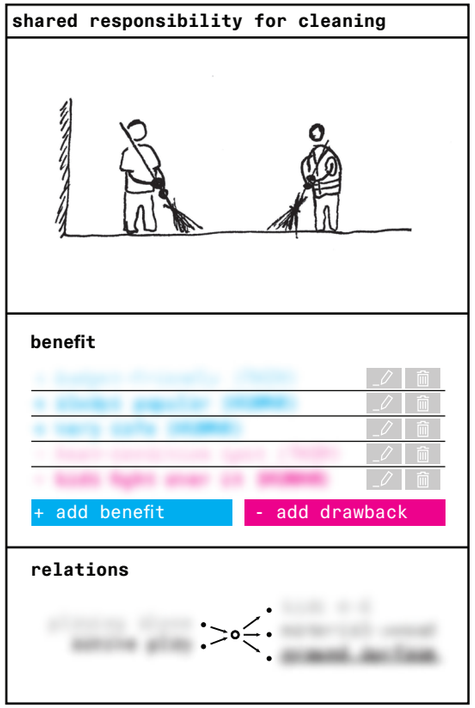


figure 53.
non-physical pattern card

ch8.conclusion sc3.recommendations

recommendation seven:

Implement a data structure that leaves traces of discussions and arguments and therefore lets developers effectively process and refer back to citizens' input.

The pattern format provides developers with rich qualitative and quantitative data to aid the final design process: patterns chosen and written by participants as well as the reasoning why they think these are a good idea or not. In a physical session if a developer is present they of course already get all this information, but recording it in this format allows it to be processed and reformatted to be of more use in policy: in the case of large quantities of data the association with patterns will help qualitative analysis tools draw connections between the various inputs of participants and recognise themes for developers to draw upon. In the case of both larger and smaller projects, these neatly grouped insights from citizens provide a proposition for the developer to respond to. If they plug the final design back into the digital twin, its various elements can be related back to the gathered insights, showing citizens how their input was used.

exploited benefit:
Urban digital twins can be used to show the link between citizens' inputs and a final design to help increase transparency and bolster the legitimacy of the decisions made.

Providing a tool to clarify the use of citizen feedback in decision making solidifies the responsibility of developers to engage with it seriously, and if done successfully can be used to increase transparency in decision making and potentially build a base of trust between citizen and municipality for successful future participatory processes.

mitigated risk:
none

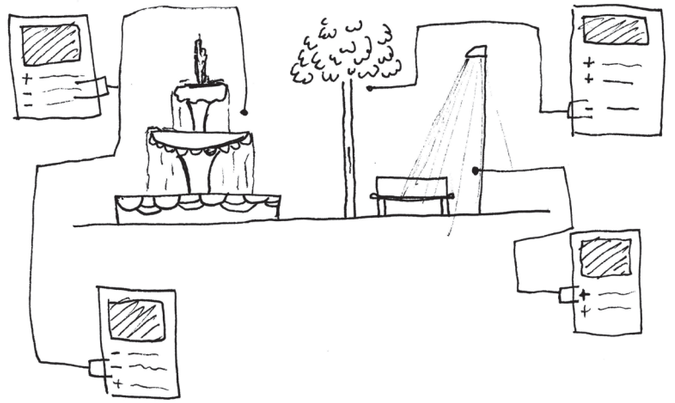
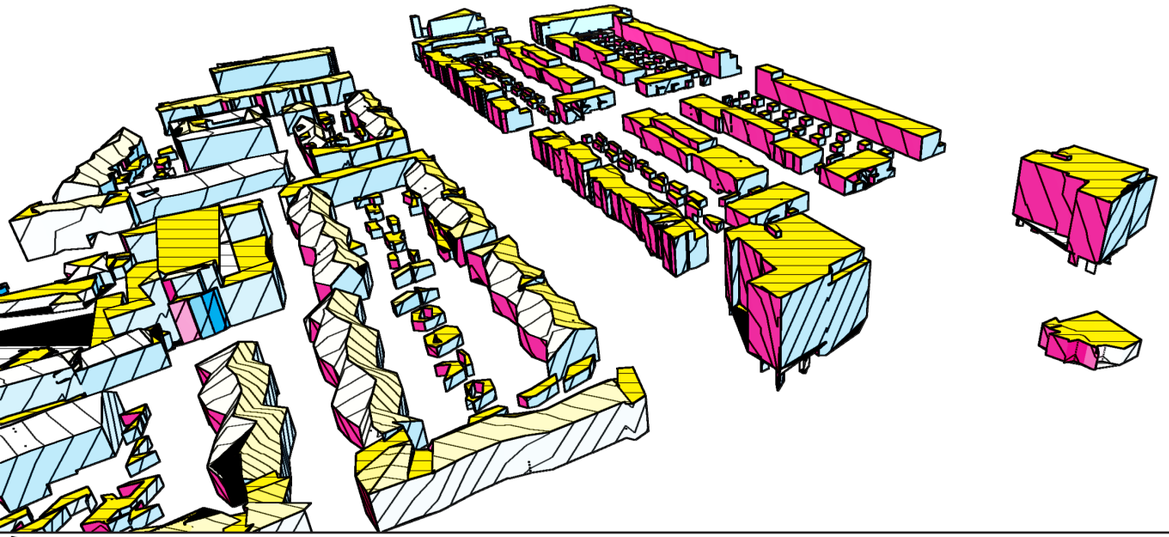


figure 54.
using the digital twin to address the needs behind patterns

NOTE ON GAMIFICATION

While some of the insights from my research, such as the value of playfulness to engage participants, may seem to imply a need or use for gamification, I have consciously avoided mentioning this in my suggestions. This is not because I find it unsuited, but because a modest body of literature on gamification in public participation already exists and while it has found promising results (Thiel, 2016), gamification in this context is understood primarily as the implementation of reward systems: achievements, experience and reputation points. This specific topic was outside the scope of my tests and interviews so to avoid confusion I have omitted the term. Nevertheless, besides pattern language and argumentation theory, my design proposal does draw heavily on principles and ideas from game design, specifically tabletop roleplaying games for their power to engage a group of people in building a world together.



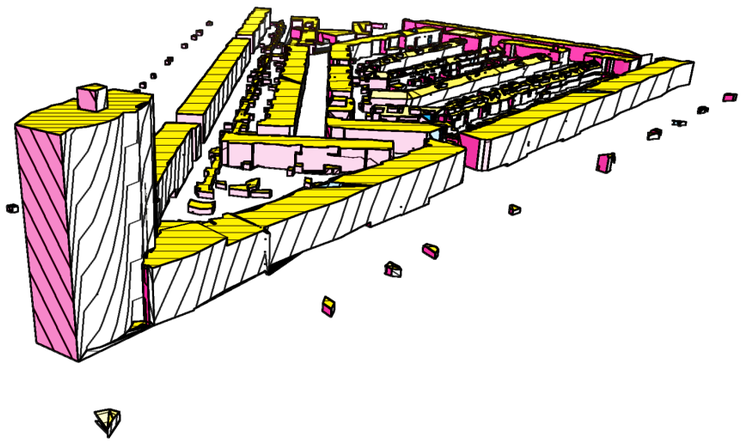
section 8.4: overall conclusion

While participant enthusiasm can enhance engagement, it also poses a risk of losing focus on essential priorities during discussions. The challenge of dominant voices in group discussions is not resolved by urban digital twins, emphasising the need for effective moderation and interaction design to harness participant input. Despite the intuitive, accessible visualisations offered by urban digital twins, social obstacles to inclusivity persist, which may require innovative solutions to ensure broader participation. Striking a balance between detailed citizen inputs and expert knowledge can be productive, provided there are effective communication and feedback mechanisms.

However, it is essential to acknowledge that digital twins, while potentially enhancing the understanding of constraints, are simplified and non-neutral representations of reality, and oversimplified projections of good or bad futures can limit creative solutions and reinforce biases if not carefully managed. In conclusion, urban digital twins have the potential to improve public participation, but their design should address these challenges to maximise their effectiveness.

I hope the provided risks, benefits and recommendations will serve as a useful tool for municipalities and companies seeking to implement urban digital twins in processes of public participation.

>end of chapter eight



Ninth chapter; Reflection

This chapter is primarily written for other design researchers. In it I reflect on key aspects of the project, starting with the methodology I applied and what this may mean for further research using speculative design methods. I then reflect on how to navigate a complex network of stakeholders in speculative design research projects, and finally I look to the future, where the insights from this thesis might go, and where I might go with them.

chapter sections

section 9.1: reflection on methodology

When I started this thesis I knew of speculative design aesthetically, but had little understanding of the goals it seeks to achieve and how it may achieve them. The following text describes the conclusions I reached about the use of speculative design throughout the course of the project. They may be well-known or obvious to experts, but were formative to my current understanding of the topic and may be useful to students and researchers setting out on a similar journey.

The core of my methodology was the Speculative Enactments method developed by Elsden et al. (2017). My specific application of this was slightly unusual in two ways: I used it to explore an already specified type of emergent technology, shifting the focus more onto the shape the technology itself might take rather than the kind of world in which it might exist. Secondly I undertook this exploration in a highly embedded way–finding a context in which the technology would realistically be used along with the people who would, in this context, realistically be the ones using it. This approach was in response to a critique that I, along with many other design theorists, have leveraged against speculative design projects: that they are disconnected from the real world, being made exclusively by and for speculative designers and design academics (Farias et al., 2022). By performing enactments with the real users in the real context, I would uncover insights that can be used to inform real development. Looking back now, I realise this approach is somewhat contrary to the core principles of speculative design as it is traditionally understood: “[Speculative design] feeds the profession’s imagination and it opens up new possibilities, not only for technology, materials, and manufacturing but also for narrative, meaning, and the rethinking of everyday life” (Dunny & Raby, 2013, p.31). Despite being based in the language and methods of speculative design, I would argue the label of speculative no longer applies to the enactments as we performed them, after all, every participant played the role of their present day selves in a scenario set in their everyday life. We were not imagining futures, but evaluating them, and that is fine.

I believe I was successful in the goal I set out to achieve: to cross the experiential gulf, the gap between audience and future, described by Candy and Dunagan (2017) and gather insights that are of interest to non-designers, ready to be immediately applied in the real world.

While looking back across the gulf, it appears that in crossing it the project became something other than speculation, not necessarily better or worse. Speculations are by their nature not of the real world and by being brought into it their purpose transforms from imagination to experimentation. I see this as a consolation and an opportunity for speculative design to evolve: for speculative designers that seek to inspire and imagine, it means they should perhaps cherish the experiential gulf as a valuable part of their practice, while for researchers in fields outside design it presents the opportunity to draw upon the language and methods of speculative design to unlock another area of insights.

This brings me to my final reflection: speculative enactments became a support for me to research public participation. I am trained as a designer, not a governance researcher, and while I was lucky enough to meet colleagues that were (and was able to steal draw inspiration from their work), so much of my time was spent doing the necessary background research to be able to make even a minor contribution to the literature on public participation technology. I am proud of the contribution I made, but I believe what this truly hints at is the potential for cross-field collaborative research: speculative design researchers working in tandem with humanities researchers can go so much further than I was able to go. If both are able to speak the same language, this may be another road for speculative design to “connect to the real world”.

section 9.2: reflection on focus and stakeholder management

The goal of the project went through considerable changes throughout its execution. In part this was the logical resolution of the contradictions in my initial intentions, as explained in the previous section, in part this was due to time constraints, as it tends to be, but in part this was also a result of stakeholder management. When I started my project, there was no ongoing research in The Hague about urban digital twins and participation for me to hitchhike onto. In spite of this, I insisted on embedding my speculations in a realistic context with realistic participants. This sent me on a chase through a complex network of stakeholders (figure 55), each with different expectations. Stakeholder management is a core part of any design project, but I have never read about stakeholder management in an (initially) speculative design project, and I doubt anything could have prepared me for it: for every link in the chain, I had to convince someone that “I’m going to build a prototype– but it doesn’t really work– but it feels like it does. And the goal is to learn about this technology– but it doesn’t really exist yet–

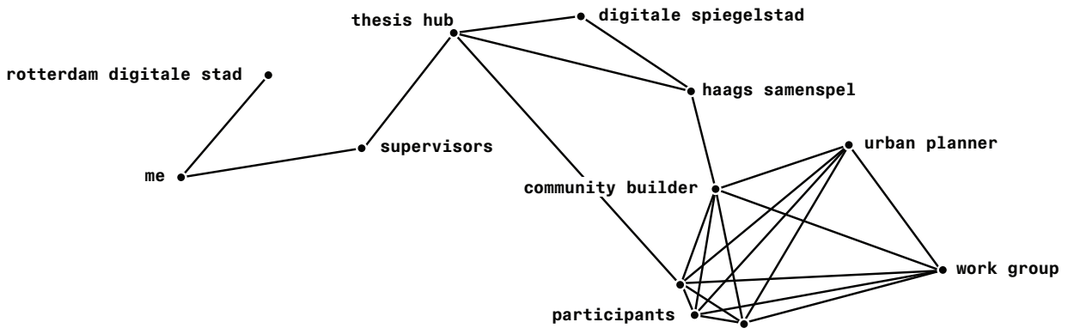


figure 55. stakeholder network

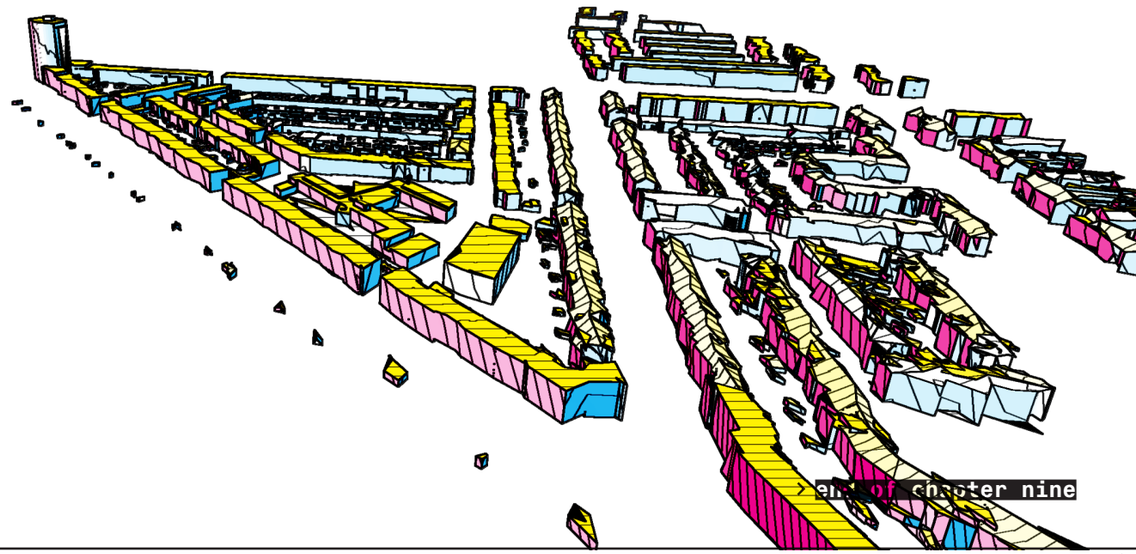
but it needs a real participatory process– but you can't really use the insights, because it doesn't really work– also there's this political theory called agonism and... but you should help me out because it's important research and it's gonna be a lot of fun!" (note: dramatisation) And as I travelled down the chain, all the while conducting interviews with civil servants and other researchers, their cumulative interest in something that was not whatever I was describing started to weigh heavily against my own initial interest, and my own intentions started to morph to accommodate them, leading the project to become increasingly more practical and less speculative in nature. With the help of my supervisors I was able to steer it back in a more interesting direction, and for the most part every stakeholder was fine with it, probably because they did not understand what I was supposed to contribute in the first place (this is a joke, sort of), and because, as promised, it was a lot of fun.

Convincing down-to-earth stakeholders of the value of design can be challenging at the best of times, and many times more so for speculative design. Ideally they will agree if we can only explain it to them properly, and while I believe we should keep trying to do so, not everyone is going to see it, and perhaps they are right not to. In these situations, providing an alternative motive like fun, or making the project more grounded in the present and accessible to a general audience, are to me, perfectly valid strategies. This too is part of bringing speculative design into the real world.

section 9.3: preflection on project continuation

As deeply embedded in the "real world" as it was, what might the actual impact of this design research project be? Early on in this thesis, we explored the critique of urban digital twins as being primarily driven by an impluse from the tech sector and lacking a critical perspective, so it is debatable what effect an academic contribution alone will have. I do, however, have reason for cautious optimism. Throughout the project I have been in close communication with the developer of the Digitale Spiegelstad in Den Haag. I have already pitched my insights to the stakeholders within the municipality. A full presentation, along with prototype demonstration, is also planned for the future. Through the Thesis Hub, I have come in contact with people from various branches of the municipality, as well as housing corporations who have expressed interest in using a similar technique in their own participatory processes.

It is my hope and intention to pursue these leads, to be able to personally contribute to the development of urban digital twins for participation, to bring my own insights into the real world.



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Appendices

Appendix A: overview of dutch digital twin initiatives

#	Project	Territory	Main Use Cases	Source
1	3D Amsterdam	Amsterdam	Communication*, participation*, simulation*	(Gemeente Amsterdam, 2022)
2	3D Rotterdam	Rotterdam	Citizen engagement, streamlining permitting process and safety.	(Gemeente Amsterdam, 2022)
3	Den Haag Digital Twin	The Hague	Monitoring pedestrian and biker flows	(Gemeente Rotterdam, 2022)
4	De Digitale Spiegelstad	The Hague	Urban planning*, co-creation*	(OTAR, 2021)
5	3D Digital City	Groningen	Project visualisation*, property registry*, management of applications for public service*	(Gemeente Den Haag, 2020)
6	3D Utrecht	Utrecht	Visualisation & simulation of building plans*	(Gemeente Groningen, 2022)
7	3D Stadsmodel	Eindhoven	Simulation of scenarios*, visualisation*	(Gemeente Utrecht, 2022)
8	Brainport Smart District Digital Twin	Brainport Smart District, Helmond	Evaluating future plans*, visualisation for residents*	(ESRI, 2021)
9	Almere Digital Twin	Almere	Improving building permit processes, visualising scenarios*, co-creation*, calculating future effects*	(GemeentenNL, 2021)
10	Den Bosch Crowd Management Dashboard	City centre of Den Bosch	Crowd management	(Argaleo, 2021a)
11	Digital Twin Zeeland	Province of Zeeland	Safety assessment*, calculating evacuation plans*	(Argaleo, 2021b)
12	Smart City Alkmaar	Alkmaar	City planning, housing provision monitoring, visualising real-time data*	(Analyze, 2022)
13	Nijmegen 3D Tweelingstad	Nijmegen	Crowd management and planning of big events, simulation and monitoring of events*	(Gemeente Nijmegen, 2022)
14	Zwolle Digital Twin	Zwolle	Simulating heat stress and rise of water levels	(Kadaster, 2021)

**: use case expanded based on original source*

Consent form for 'Design speculations for participatory digital twins' study

You are invited to participate in a research study titled DESIGN SPECULATIONS FOR PARTICIPATORY DIGITAL TWINS. This study is being done by David Tiemstra from TU Delft as part of his master's thesis.

The purpose of this research study is to explore views on the use of city digital twins in participatory city making.

Participation will take approximately 60 minutes and includes (1) a group discussion about your personal views on the use of digital tools for citizen participation, specifically urban digital twins, this discussion may touch upon politically controversial topics. (2) An experiment where you, together with other participants, will be asked to interact with a digital prototype of a participatory digital twin application and comment on the experience.
The data will be used in academic presentation and publication, and to inform the further development of the prototype.

To the best of our ability the data you will provide in this study will remain **anonymous and confidential**. We will minimize any risks by completely maintaining your anonymity and storing the data on password protected devices. You will be given the chance after the interview to withdraw permissions.

Your participation in this study is entirely voluntary and you can withdraw at any time by contacting …

Please tick the appropriate boxes	Yes	No
I have read and understood the study information or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, wtithout having to give a reason.	☐	☐
I understand that taking part in the study involves an interview and an experiment with a digital prototype (which includes a screen recording of my interaction).	☐	☐
I understand that any other personal information collected about me that can identify me, such as my name, address, telephone number or email address, will not be shared beyond the study team.	☐	☐
I give permission for a confidential audio recording to be made of the interview and experiment.	☐	☐
I give permission for the (anonymized) information I provide (including a screen recording of my interaction with the prototype) to be used for academic presentations and publications.	☐	☐
I give permission for my contact information, such as telephone number or email address, to be stored over the duration of the research to contact me at a later time.	☐	☐
I agree that my responses, views or other input can be quoted anonymously in research outputs	☐	☐

Please tick the appropriate boxes	Yes	No
I give permission for the (anonymized) outcome of my interaction with the prototype to be archived in a research repository so it can be used for future research and learning.	☐	☐
I agree to be contacted for participation in a follow-up study.	☐	☐

SIGNATURES

_____	_____	_____
Name of participant [printed]	Signature	Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Researcher name [printed]	Signature	Date

For further information contact ….

Toestemmingsformulier voor het onderzoek 'Design speculaties voor participatieve digital twins'

U wordt uitgenodigd om deel te nemen aan een onderzoek getiteld DESIGN SPECULATIES VOOR PARTICIPATIEVE DIGITAL TWINS. Dit onderzoek wordt uitgevoerd door David Tiemstra van de TU Delft als onderdeel van zijn masterscriptie.

Het doel van dit onderzoek is om meningen te onderzoeken over het gebruik van digital twins in participatieve stedenbouw.

Deelname duurt ongeveer 60 minuten en omvat (1) een groepsdiscussie over uw persoonlijke opvattingen over het gebruik van digitale hulpmiddelen voor burgerparticipatie, in het bijzonder stedelijke digitale tweelingen. (2) Een test waarbij u, samen met andere deelnemers, wordt gevraagd om te interacteren met een digitaal prototype van een participatieve digital twin toepassing en commentaar te geven op de ervaring.
De gegevens zullen worden gebruikt voor academische presentatie en publicatie, en om de verdere ontwikkeling van het prototype te informeren.

Naar ons beste vermogen zullen de gegevens die je in dit onderzoek verstrekt anoniem en vertrouwelijk blijven. We minimaliseren eventuele risico's door uw anonimiteit volledig te bewaren en de gegevens op te slaan op apparaten die beveiligd zijn met een wachtwoord. U krijgt na het interview de kans om uw toestemming in te trekken.
Uw deelname aan dit onderzoek is geheel vrijwillig en u kunt zich op elk moment terugtrekken door contact op te nemen met ...

Vink de toepasbare vakjes aan	**Ja**	**Nee**
Ik heb de informatie over het onderzoek gelezen en begrepen of deze is mij voorgelezen. Ik heb vragen kunnen stellen over het onderzoek en mijn vragen zijn naar tevredenheid beantwoord.	☐	☐
Ik geef vrijwillig toestemming om deel te nemen aan dit onderzoek en begrijp dat ik kan weigeren vragen te beantwoorden en dat ik mij op elk moment, zonder opgaaf van reden, uit het onderzoek kan terugtrekken.	☐	☐
Ik begrijp dat deelname aan het onderzoek bestaat uit een interview en een test met een digitaal prototype (inclusief een schermopname van mijn interactie).	☐	☐
Ik geef toestemming voor het maken van een vertrouwelijke geluidsopname van het interview en de test.	☐	☐
Ik geef toestemming om de (geanonimiseerde) informatie die ik geef (inclusief een schermopname van mijn interactie met het prototype) te gebruiken voor academische presentaties en publicaties.	☐	☐
Ik geef toestemming om de (geanonimiseerde) informatie die ik geef (inclusief een schermopname van mijn interactie met het prototype) te gebruiken voor academische presentaties en publicaties.	☐	☐

Vink de toepasbare vakjes aan	Ja	Nee
Ik geef toestemming dat mijn contactgegevens, zoals telefoonnummer of e-mailadres, gedurende de looptijd van het onderzoek worden opgeslagen om op een later moment contact met mij op te kunnen nemen.	☐	☐
Ik geef toestemming dat mijn antwoorden, meningen of andere input anoniem geciteerd mogen worden in onderzoeksresultaten.	☐	☐
Ik geef toestemming om het (geanonimiseerde) resultaat van mijn interactie met het prototype te archiveren in een onderzoeksarchief zodat het gebruikt kan worden voor toekomstig onderzoek en leren.	☐	☐

HANDTEKENINGEN

_____ _____ _____

Naam van deelnemer Handtekening Datum

Ik, als onderzoeker, heb het informatieblad nauwkeurig voorgelezen aan de potentiële deelnemer en mij er, naar mijn beste vermogen, van verzekerd dat de deelnemer begrijpt waarmee hij/zij vrijwillig instemt.

_____ _____ _____

Naam van onderzoeker Handtekening Datum

Neem voor meer informatie contact op met …

Digital Twins for participatory citymaking with design speculations

project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 06 - 04 - 2023

06 - 10 - 2023 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

General context
Municipalities have been quick to embrace urban digital twins (UDTs) as drivers for Smart Cities. The city of The Hague is one such municipality, working on a project they call the 'Digitale Spiegelstad' [1].

Urban digital twins are virtual, 3D representations of one or several dimensions of a city that draw from static and dynamic data [2].
One of the first UDTs was Virtual Singapore, the proposal of which in 2014 [3] already proposed an ambitious list of use purposes: (1) optimization of systems such as public service and infrastructure, (2) a decision making platform: evaluating the impact of proposed changes before they are made through simulation, as well as using the digital twin as a direct voting platform. (3) A platform to facilitate easier communication and sharing of data between different sectors. These are still the most commonly proposed purposes for digital twins today [2].

It has been argued that traditional community engagement activities fail to reach citizens that are time-poor, younger, or culturally diverse, making them non-inclusive and fragmenting to communities, and the use of new digital participation techniques may be used to achieve more genuine engagement [4]. Present research suggests that digital twins can offer various benefits to participatory processes, such as more intuitive engagement for citizens leading to a more diverse intersection of society being willing and able to participate [5,6]. This is good for the municipality since greater engagement means a bigger support base for decisions. Additionally, with a model capable of integrating diverse data, rich participation results could be effectively processed to be used to inform policy on a local scale (the concept of "maatwerk" which the municipality values).

To scope the project I will explore the application of the DT within the context of one specific participatory process, happening in The Hague Southwest. The domain is yet to be determined but I have proposed urban green spaces. This domain is interesting for the municipality because it contributes to SDGs 15 and 11, and exposure to urban green spaces is linked with lower mortality and violence and better mood and physical activity [7]. Additionally, its spatial nature lends itself well to the use of a 3D city model and its impact on climate in the city to the use of simulation. Projects in this domain are usually managed by the Dienst Stedelijke Ontwikkeling (DSO).

This project will take place within the Thesis Hub The Hague Southwest project of Leiden-Delft-Erasmus, this has helped me get in contact with the municipality and will support me with citizen research.
I will collaborate with different departments of the city of The Hague: the Digitale Spiegelstad development team, headed by Stefan Los, as well as Haags Samenspel, responsible for citizen participation in The Hague, including contact person Berit Piepgras. They will connect my project to a specific participatory process happening in The Hague Southwest so the team in charge of this will also be a stakeholder.

space available for images / figures on next page

introduction (continued): space for images

image / figure 1: The Hague's Digital Twin

image / figure 2:

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

The municipality of The Hague has stated that the original purpose of their DT was to support communication and visualisation in participatory applications [1]. The 3D model has been finished and can be viewed online [8], but is not yet ready to be used in participatory practices, and the municipality is still exploring the participatory potentials of the DT. One concern, discussed in personal contact with Stefan Los, is the uncertainty about issues that will emerge when applying the model in the real world. This will be my problem space, I now foresee issues arising in the following areas:
1. Trust: what could be the consequences of simulating the outcome of a decision in a deterministic data-based model? How would it account for contingencies? Predictions as calculated by an advanced and complex model can appear convincing despite being flawed or incomplete, and using these predictions in a decision-making process can lead participants to favour certain decisions over others, making the design of the model also politically contentious.
2. Understanding: how well will participants be able to understand what's going on beneath the surface? And how much should they need to understand in order to make good use of the tool? Their level of knowledge about the inputs and how they are processed, may impact the participants' trust in the process and the predictions. Knowing where the information they are presented with comes from also gives participants the ability to contest it, influencing the power dynamics of the process.
3. Legibility & accessibility: how are participants invited to interact with the model, and how does the design of this interaction influence the decision-making process? The ways in which information derived from and about the model is presented to the participant are important to trust and understanding, and the affordances and the way they are signified are important to a participant's understanding of the power they hold in the process.
These are three complex problem areas that are closely interlinked. While present research has pointed to the potential of the digital twin in future city participation, the user experience is yet to be seen in realistic or tangible applications [9]. Therefore, the role I see for my project is to anticipate the types of issues that may arise in these areas and what can be done now to account for them.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

By creating a future vision together with citizens in generative speculative sessions, I want to envision how a digital twin could be used for participatory city making. By materialising this vision and bringing it back to policy makers and citizens, I want to help push the debate around urban digital twins beyond "can we?" and into "how should we?".

When the participatory digital twin is put into practice, implications will unfold that we cannot currently predict based on any historical data, because of this speculative enactment [10] is an appropriate methodological approach to anticipate the type of issues brought forth in the previous section. It creates the conditions for social interactions amidst speculation, which is crucial for these problems and possible alternatives to emerge. I want to create a vision of what a participatory application of a DT could look like in The Hague, and materialise it for an enactment with citizens and civil servants. The point of this enactment is to bring to the surface issues and opportunities that had previously not been considered.
I intend to develop this vision for one specific decision-making process.
Nochta et al. (2020) suggest that to avoid the pitfalls of fake participation and "hype technology", the development of such participatory digital twin applications should be locally specific and participatory. It is also my personal belief that citizens should be involved in the design and application of technologies that affect them personally. For these reasons I want my envisioned application to be co-created with citizens living in the chosen context.

In response to the problem raised, the main research question I want to answer is:
How can the digital twin of The Hague serve as a means for participatory city making that facilitates inclusive and empowering citizen engagement?

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PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 6 - 4 - 2023 6 - 10 - 2023 end date

Date	3.4	10.4	17.4	24.4	1.5	8.5	15.5	22.5	29.5	12.6	19.6	26.6	10.7	31.7	21.8	28.8	4.9	11.9	18.9	25.9	2. 10	>
Calender week	14	15	16	17	18	19	20	21	22	24	25	26	28	31	34	35	36	37	38	39	40	>
Project week	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	>
Assessment moments																						
Kick-off	6.4																					
Midterm evaluation									2.6													
Green light meeting																	5.9					
Graduation ceremony																						
Thesis hub meetings																						
Kick-off	29.3																					
Workshop		12.4																				
Workshop											19.6											
Final Meeting																			13.9			Feb/24
(1) RESEARCH PHASE																						
UDT & digital participation research	x	x	x																			
Domain research*			x	x																		
Municipality expert interviews				x	x																	
Opportunity & plausibility mapping					x	x																
(2) SPECULATIVE DESIGN																						
Co-specuation methodology research		x		x																		
Shaping speculative tools					x	x																
Participant recruitment*						x																
Co-speculative session							x															
Analysis							x	x														
Scenario & conept development								x	x													
Prototyping technique exploration			x		x		x		x	x												
Building experiential prototype										x	x	x	x	x	x							
(3) REFLECTION																						
Speculative enactment research										x	x		x									
Planning/recruitment*											x	x	x									
Pilot enactment														x								
Revisions														x								
Spatial & interface setup														x	x							
Execute enactment*																x						
Analysis																	x					
Composing guidelines																		x				
REPORTING																						
Visualization technique exploration	x	x				x								x	x							
Report building								x	x							x	x	x	x	x	x	
Presentation								x	x							x	x			x	x	

Approach

I will address the research questions by drawing on the taxonomy developed by Farias et al. [11]:

1. During the initial research phase I will be mapping the technical and social opportunities and limitations of UDT technology in this context through interviews and desk research.
2. In the second stage I will help to shape a future vision for the UDT's participatory application through citizen co-speculation sessions.
3. Speculative enactment and critical reflection: getting as many stakeholders as possible to engage in the vision and debate its implications to define the next steps for the development of the UDT.
4. Generate a guide. the end result will consist of two parts: the speculative vision of the UDT application, its materialisation as used in the enactment, and the results of the reflection.

Schedule

I will be working full time on the project, with a few breaks in between. Attaching my project to the Thesis Hub initiative presents some minor obligations with regard to the schedule.

As I have currently formulated my assignment it depends on both co-speculation sessions with citizens at the start of the project, as well as a session with citizens and public servants. My contacts within the municipality have offered to connect my project to a real participatory procedure happening in The Hague Southwest. This will help ensure that the project is concrete, relevant, and reaches the right people, but it also means I might have to be flexible with my planning to fit the process.

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MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

The first reason this project came on my radar was because of a growing interest in speculative design and a strong desire to try it out before the end of my studies. I have always liked to do regular projects in an unconventional way, to try and reach results that were original and showed alternative possibilities to solve a problem, but have found this sometimes hard to reconcile with providing a tangible benefit through design and I believe speculative design theory perfectly captures how unconventional propositions can provide a benefit.
This context then, provides the perfect opportunity: a developing technology with great potential that seems to be held back by a lack of original or diverse visions of the future, which also connects well to my other ambitions and competencies:
1. Experiential digital prototyping: during my MSc I have become much more skilled with more advanced digital prototyping using different software and programming languages (ITD, UXAD, Joint Master Project) as well as creative coding through my work for Visual Communication Design. One of my main ambitions for this project is to prototype future interfaces that convey strong and unique experiences through their interaction and that can serve as an example of the potential of interactive media as a tool for speculative design, as well as my own technical and visual skills.
2. Public design: I've come to believe I would like to work outside the commercial sector as a designer and have researched public design literature during my first-semester-courses, so I would like to finally develop real experience with design work for a municipality.
3. (Urban) design theory and research: I want to develop a deep understanding of contemporary literature about design and urban planning. During courses such as DTM and Design and the City I discovered I like exploring these concepts and I would like to challenge myself to see where I can make a contribution to the field of design in city-making and participatory speculative design (as a research method) .
4. Participatory practice: while I have gained a lot of experience conducting and analysing interviews during my electives, I lack experience in organising actual co-design sessions, a skill which I think is especially important for the aforementioned fields of public and urban design.

[1] Gemeente Den Haag (2020). Datastrategie 2020-2022: Dataverhalen voor de stad.
[2] Shahat, E., Hyun, C. T., & Yeom, C. (2021). City digital twin potentials: A review and research agenda. In Sustainability (Switzerland) (Vol. 13, Issue 6). MDPI AG. https://doi.org/10.3390/su13063386
[3] National Research Foundation Singapore. (2014). Virtual Singapore. Nrf. Retrieved January 8, 2023, from https://www.nrf.gov.sg/programmes/virtual-singapore
[4] Fredericks, J., Hespanhol, L., Parker, C., Zhou, D., & Tomitsch, M. (2018). Blending pop-up urbanism and participatory technologies: Challenges and opportunities for inclusive city making. City, culture and society, 12, 44-53.
[5] Dembski, F., Wössner, U., Letzgus, M., Ruddat, M., & Yamu, C. (2020). Urban digital twins for smart cities and citizens: The case study of Herrenberg, Germany. Sustainability (Switzerland), 12(6). https://doi.org/10.3390/su12062307
[6] Jansma, S. (2023) Participatie met Digital Twins: iedereen doet mee op haar eigen manier.
[7] Kondo, M. C., Fluehr, J. M., McKeon, T., & Branas, C. C. (2018). Urban green space and its impact on human health. International journal of environmental research and public health, 15(3), 445.
[8] Gemeente Den Haag, Future Insight Group BV. (2019). Den Haag in 3D. https://www.nederlandin3d.nl/denhaag/#/
[9] Saeed, Z. O., Mancini, F., Glusac, T., & Izadpanahi, P. (2022). Future City, Digital Twinning and the Urban Realm: A Systematic Literature Review. In Buildings (Vol. 12, Issue 5). MDPI. https://doi.org/10.3390/buildings12050685

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

[10] Elsden, C., Chatting, D., Durrant, A. C., Garbett, A., Nissen, B., Vines, J., & Kirk, D. S. (2017). On speculative enactments. Conference on Human Factors in Computing Systems - Proceedings, 2017-January, 5386–5399. https://doi.org/10.1145/3025453.3025503
[11] Farias, P. G., Bendor, R., & Van Eekelen, B. F. (2022, August). Social dreaming together: A critical exploration of participatory speculative design. In Proceedings of the Participatory Design Conference 2022-Volume 2 (pp. 147-154).

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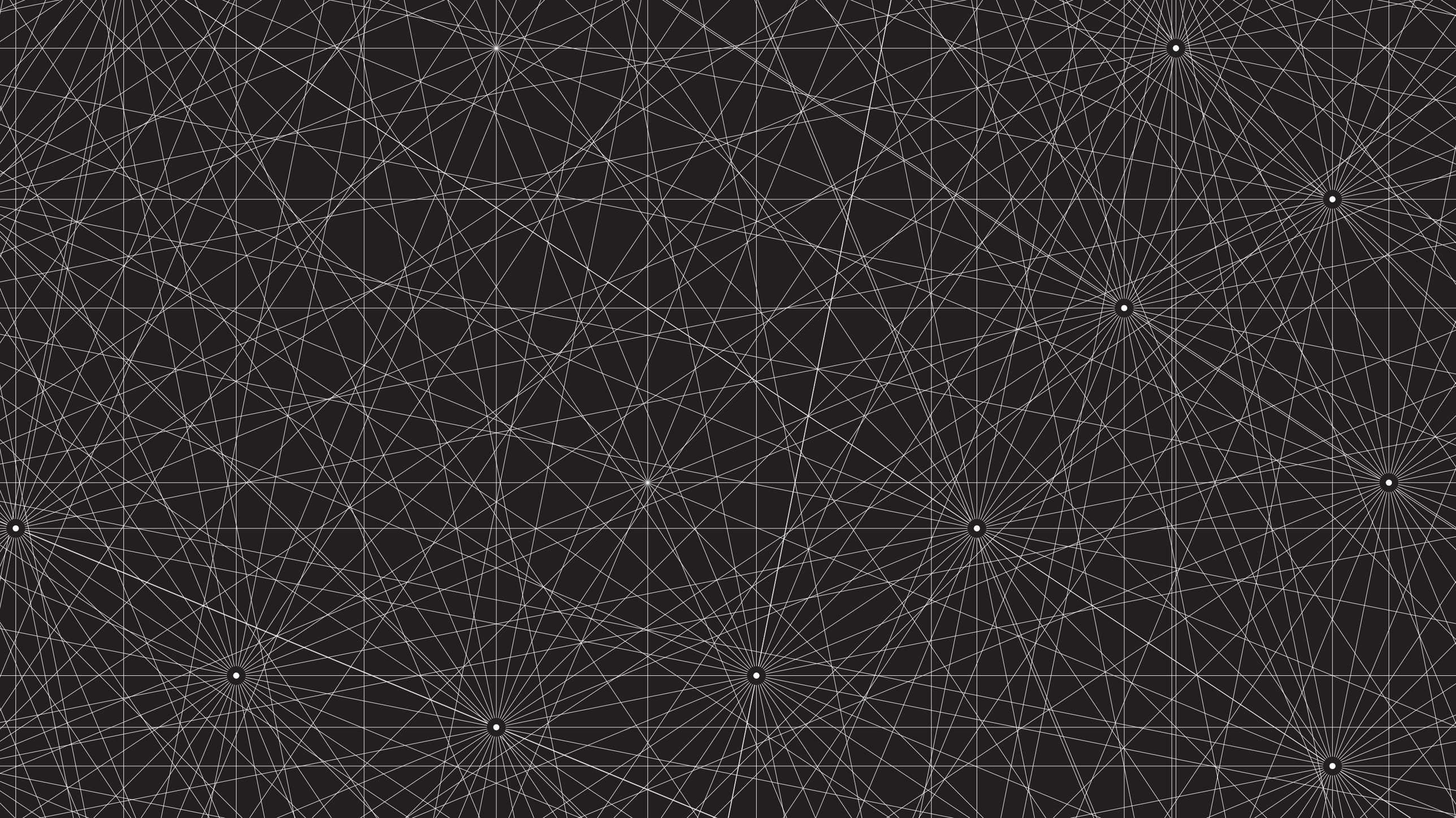

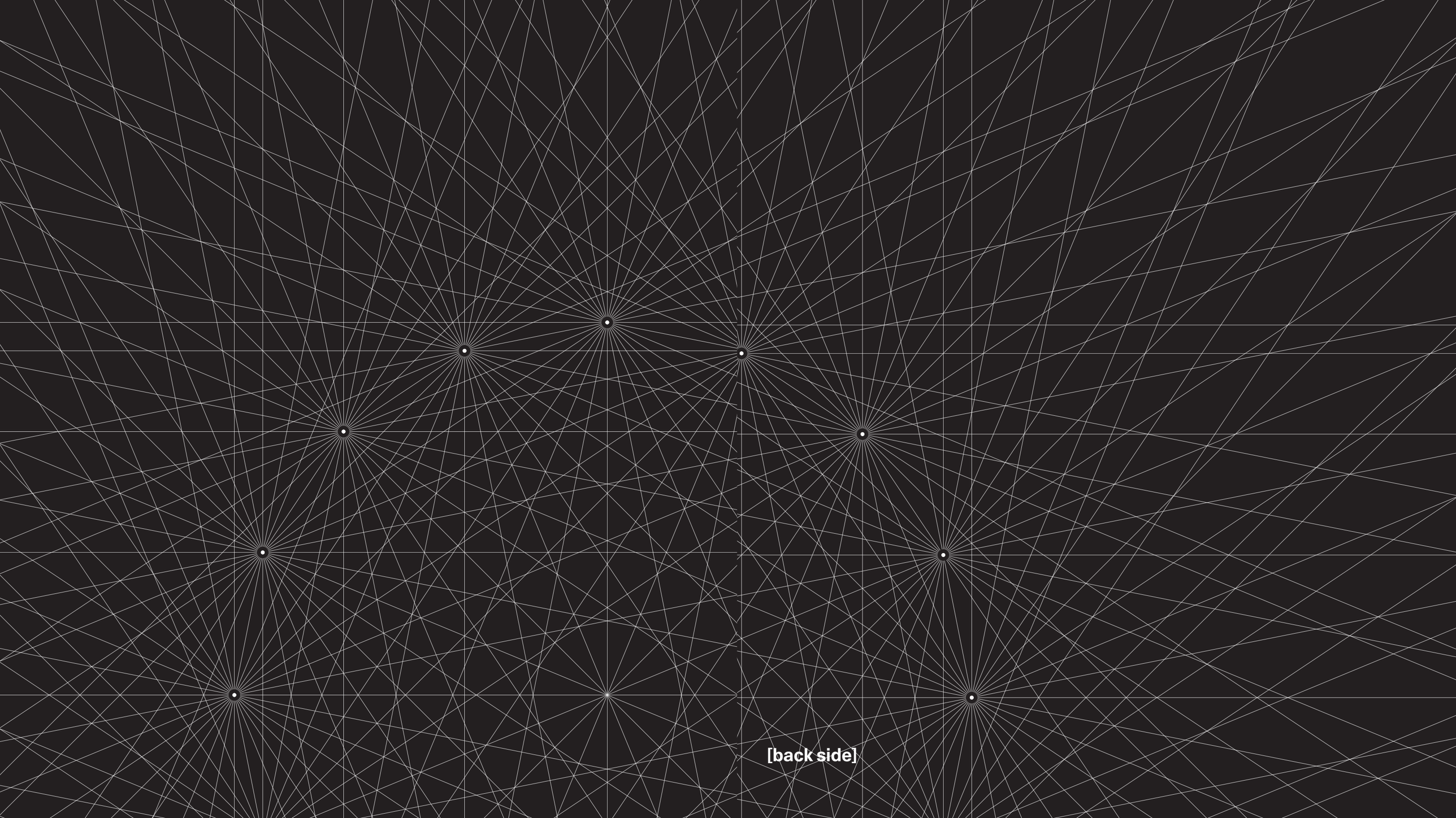
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