Co-Creating the Digital City:

Suggesting Principles of Multi Stakeholder Collaboration in Delivering Urban Technologies

Dissertation

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Abstract

Cities worldwide are adapting digital technologies and data-driven tools for planning and managing, and in many digital city strategies, citizen centricity, participatory principles and co-creative concepts are put at the center of digitization efforts. However, these measures oftentimes stay behind their promises of sharing agency or delivering better results. Reasons for this are, among others, an oftentimes ill-defined conceptualization of co-creation resulting in insufficient methodologies of engagement, and the failure to regard technology as a socio-technical arrangement that manifests scientific, democratic and political orders. This dissertation sets out to examine these arrangements by testing co*-principles as a methodology to collaborate on the development of urban technologies and data-driven tools with diverse stakeholders, and to suggest design principles for a transformational digital urban practice.

In examining three applied case studies located in the Federal State and City of Hamburg, Germany, this research sets out to design, test and analyze co*-methodologies as a function of, as a starting point, and as the principle for developing digital and data-driven tools. It examines co-creation with the general public, with vulnerable groups, and with expert stakeholders, in relation to the development of a Participatory Platform, a combined Website and App, and a Digital Urban Twin. The research is guided by the question *How can participatory and co-creative principles be employed in the development of urban technology and data driven tools, and how does their implementation transform perspectives, knowledge, and agency within the digital city?* It does so by designing and testing Usability and User Experience Studies, Co-creation workshops, and Co-modelling procedures. This dissertation introduces a novel tool to analyse and design Co-creation activities, the Co-creation Nucleus. By mapping the three case studies on the Co-creation Nucleus, this research investigates the reconfiguration of stakeholder constellations, novel forms of thinking and acting with and through digital tools, and the emergence of agency and ownership through co-creation.

This research finds that digital tools can help broaden outreach and unveil implicit knowledge. However, it also points out limitations in terms of inclusiveness of stakeholders, variety of practices, and the extent of agency emerging from co*-activities. It illustrates strategies to strengthen stakeholder engagement throughout longer project phases. By testing and analyzing methodologies for co-creation with the general public, vulnerable groups, and experts, this research gives insights into the design requirements for co-creation with diverse stakeholder constellations. In describing the co-modelling of a Digital Twin, this research shares knowledge on the collaborative exploration of complex urban challenges.

The analysis of the three case studies reframes the existing discourse on co-creation in digital cities. This investigation develops novel approaches and suggests new ways of producing and implementing urban technologies that take into account urban complexity and diverse stakeholder perspectives. In doing so, this dissertation offers scientists and practitioners valuable co*-principles to shape the future of their cities.

Zusammenfassung

Weltweit setzen viele Städte digitale Technologien und datengesteuerte Werkzeuge ein, und zugleich werden in vielen Digitalstrategien Co*-Prinzipien wie Bürger:innenorientierung, Partizipation und co-kreative Konzepte in den Mittelpunkt der Digitalisierungsbemühungen gestellt. Allerdings bleiben viele Co*-Prozesse hinter ihren Versprechungen zurück, Verantwortung zu teilen und bessere Ergebnisse zu liefern. Gründe dafür sind unter anderem eine oft unzureichende Definition von Co-Kreation die zu insuffizienten Methoden der Zusammenarbeit führt und das Versäumnis, Technologie als sozio-technisches Arrangement zu betrachten, das wissenschaftliche, demokratische und politische Ordnungen manifestiert. In dieser Dissertation werden diese Arrangements untersucht, indem Co*-Prinzipien als Methodik für die Zusammenarbeit bei der Entwicklung von städtischen Technologien und datengesteuerten Werkzeugen mit verschiedenen Interessengruppen erprobt werden.

Im Rahmen der Untersuchung von drei angewandten Fallstudien in der Freien und Hansestadt Hamburg zielt diese Forschung darauf ab, Co*-Methoden als Prinzip für die Entwicklung digitaler und datengesteuerter Werkzeuge zu entwickeln, zu testen und zu analysieren. Die Arbeit untersucht die Co-Kreation mit der allgemeinen Öffentlichkeit, mit vulnerablen Gruppen und mit Expert:innen in Bezug auf die Entwicklung einer partizipativen Plattform, einer kombinierten Website und App sowie eines Digitalen Urbanen Zwillings. Die Forschung wird von der Frage geleitet: Wie können partizipative und co-kreative Prinzipien bei der Entwicklung von städtischer Technologie und datengesteuerten Werkzeugen eingesetzt werden und wie verändert ihre Umsetzung Perspektiven, Wissen und Handlungsmöglichkeiten innerhalb der digitalen Stadt? Dazu werden Usability- und User Experience-Studien, Co-Kreation-Workshops und Co-Modelling-Verfahren entwickelt und getestet. In dieser Dissertation wird ein neuartiges Instrument zur Analyse und Gestaltung von Co-Kreation vorgestellt: der Co-Kreation Nukleus. Durch die Abbildung der drei Fallstudien mithilfe des Co-Kreation Nukleus werden die Neukonfiguration von Stakeholder-Konstellationen, neuartige Formen des Denkens und Handelns mit digitalen Tools sowie das Entstehen von Handlungsmacht und Eigenverantwortung untersucht.

Diese Untersuchung zeigt, dass digitale Werkzeuge dazu beitragen können, Reichweite zu erhöhen und implizites Wissen zu enthüllen. Sie zeigt jedoch auch Grenzen hinsichtlich der Einbeziehung von Stakeholdern, der Vielfalt der Praktiken sowie hinsichtlich des Ausmaßes der aus Co*-Aktivitäten entstehenden Handlungsmacht auf. Durch die Erprobung und Analyse von Methoden der Co-Kreation vermittelt diese Untersuchung Wissen über die kollaborative Erforschung komplexer städtischer Herausforderungen.

Die Analyse der betrachteten Fallstudien erweitert den bestehenden Diskurs über Co-Kreation in digitalen Städten. Diese Dissertation entwickelt neue Ansätze für die Produktion und Implementierung städtischer Technologien und schlägt Gestaltungsprinzipien für eine transformative digitale städtische Praxis vor, die die Komplexität der Stadt und die verschiedenen Perspektiven der Beteiligten berücksichtigen. Auf diese Weise gibt diese Dissertation Wissenschaftler:innen und Praktiker:innen wertvolle Co*-Prinzipien für die Gestaltung der Zukunft ihrer Städte an die Hand.

List of contents

List of publications

The following scientific articles were published within the scope of this dissertation.

Paper 1

Thoneick, R. (2021). Integrating Online and Onsite Participation in Urban Planning: Assessment of a Digital Participation System. *International Journal of E-Planning Research*, *10*(1), 1–20. https://doi.org/10.4018/IJEPR.2021010101

Paper 2

Thoneick, R., Malchow, M., Breckner, I., & Noennig, J. R. (2021). Complex arrival procedures as a challenge in migration studies: A comparative analysis of quantitative and qualitative methodologies within migration research. In L. Van Praag (Ed.), *Co-creation in Migration Studies. The Use of Co-creative Methods to Study Migrant Integration Across European Societies*. CeMIS Migration and Intercultural Studies. https://doi.org/10.11116/9789461664013

Paper 3

Thoneick, R. (2023). Co-creative Twinning: Participatory Practices and the Emergence of Ownership in Digital Urban Twins. *Conference Proceedings of the STS Conference Graz 2023*. Critical Issues in Science, Technology and Society Studies, TU Graz. https://doi.org/10.3217/978-3-85125-976-6-19

1 Introduction

1.1 Motivation and Research Gap

The departure point for the presented research is the observation that while cities are increasingly embracing co*-principles in their digital strategies, the efforts remain ill-defined and their effects can seem limited. This dissertation organises the conclusions drawn from three implementation projects carried out in Hamburg exactly in this thematic range and thus provides a valuable resource for co-creators in the digital city. This cumulative thesis addresses the research gaps by actively engaging in the co-development of urban technologies with a diverse group of stakeholders, developing novel approaches for a transformative collaboration in digital cities[1], and reflecting on the constructed, emergent, and interconnected aspects of digital participatory urbanism. In this research, participation and co-creation are not merely a starting point or a result of the development of urban technologies; they are the very foundation upon which these technologies are built. In the three individual research papers, it tests technologies that are being applied for urban co-creation, and experiments with the co-creation of urban technologies during their development. Co-creative efforts in this thesis were targeted at the general public (Paper I), vulnerable groups (Paper II), and expert groups (Paper III). This thesis designs and examines methodologies to directly involve users and a diverse set of stakeholders in every phase of the development process of urban IT projects, allowing them to collaborate on decisions about the technologies that govern their cities. In doing so, this research examines if and how technological solutions do indeed improve with the input of more stakeholders, and to what extent ownership is transmitted through co-creative efforts. This thesis examines the development of three concrete and applied technological solutions, a participatory platform, a mobile app, and a co-modelling software within a Digital Twin Framework. Specifically, this research brings the reflection and research of Co-Creation in Digital Cities a step forward by

- Examining and analysing diverse practices of participation and co-creation in the development of urban technologies
- Describing applied approaches and specific software solutions within applied research projects
- Approaching the topic from a multi-disciplinary and applied real-world perspective thanks to a collaboration with software engineers and social scientists
- Devising new forms of collective experimentation and curating novel forms of participation and co-creation
- Analysing transformational change emerging from this practice in terms of ownership and agency

In other words, engaging in the co-development of urban technologies with a diverse set of stakeholders and reflecting on the constructed, emergent, and interconnected realities of digital participatory urbanism are the core interests of the research presented in this cumulative dissertation. In it, collaboration is viewed not just as a starting point for, or an outcome of, the development of

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[1] In contrast to the term ‘smart city’ which carries the normative statement of a ‘more intelligent’ city, this dissertation uses the term *digital city* to describe cities whose administrations implement digital strategies, and where an ecosystem of companies and researchers produce and deploy technology for urban governance and management (see also Kitchin, 2016).

urban technologies, but as the very means to build these. After specifying the research gaps and documenting the necessity for this research, the remainder of this chapter will present a summary of the three papers comprising this dissertation, and outline my Main Research Question, the Research Objectives and Paper-specific Research Questions.

Technology plays an increasingly important role in urban production, and governments and administrations worldwide have issued policies, guidelines, and marketing strategies for the 'Smart', 'Intelligent' or 'Digital' City. These technologies carry the potential of delivering more efficient and effective answers to urban challenges in the eye of the polycrisis, where cities worldwide are grappling with effects of the climate collapse, technological disruptions, and social inequalities (*Future Cities: A Transatlantic Townhall Project*, 2023; Torkington, 2023). In the light of such complex challenges as mass migration, extreme weather events, and rising social segregation, cities are in need of strategies towards an ecologically and socially sustainable transformation. To order to design the conditions for transformational processes, actors from civil society, politics and economy must be enabled to improve the conditions for sustainable change; with this aim, an interdisciplinary collaboration as well as knowledge exchange is called for (Schneidewind, 2014). Increasingly, cities and governments worldwide call for principles of collaboration in their digital city initiatives. In the "New Leipzig Charta", participation and co-creation are described as crucial strategies towards a sustainable transformation and a necessity for responses to rapidly changing conditions (*Neue Leipzig Charta: Die Transformative Kraft Der Städte Für Das Gemeinwohl*, 2020, 7). Likewise, the United Nations human settlement program UN-Habitat started a process in 2023 to develop international guidelines on 'people-centered smart cities', and is expected to present its results in 2025. A meaningful collaboration of heterogenous stakeholders will become a key competence that can enable city planners, decision makers, and citizens alike to tackle the complex challenges of today (Weber & Ziemer, 2022, 25). This dissertation sets out to qualify collaboration – not just as a function of urban technology and data-driven tools, but as the very means to build it, and formulates pathways towards a transformative co-creative practice in the digital city.

Parallel to the 'co*-principles' becoming increasingly popular in digital cities, digital urban technologies and tools are already firmly embedded in many smart cities, carrying in them a variety of promises and perils. Internet of Things applications, urban sensors, open data platforms, big data, and blockchain transform how urban agglomerations are governed, how buildings and neighborhoods are planned, and how energy grids and traffic are managed (Angelakis et al., 2016; Karvonen et al., 2018; Kitchin et al., 2018; Silva, 2022). In recent years, algorithmic decision making (or 'artificial intelligence') and digital twins emerged as critical components of digital cities (Farsi et al., 2020; Hudson-Smith, 2022). The potential of urban technologies have been discussed, researched and examined, particularly in relation to their support of participatory democracy. Digital technologies and new planning tools rapidly transform public administration into increasingly advanced and more mature forms of e-government (Silva, 2022), new machine-learning technologies can improve the effectiveness of citizen participation and collective intelligence processes (Arana-Catania et al., 2021); and new possibilities for engagements of multiple actors invite external collaboration for policy design and implementation, thus having the potential of increasing transparency and restoring trust in institutions (Noveck, 2015; Randma-Liiv & Lember, 2022).

While participatory principles have been influential on smart city policies, many of them fail to regard technology as a power structure in and of itself that governs how participatory processes are

structured and implemented, thereby reinforcing existing power structures. The hidden assumptions in digital and technological systems are seldom openly debated (O'Neil, 2016). Furthermore, digital participation is oftentimes disentangled from administrative workflows and runs the risk of staying disconnected, failing to develop transformational potential (F. Harvey et al., 2022). As a result, a growing body of literature finds that urban technology at times fails to meet the promises: "In spite of great expectations and promising preliminary evidence, it may be the case that open data, crowdsourcing and other technologies may not be capable of providing deep understanding on real-life developments and citizens' needs" (Lember, 2018, 124). One reason is that while the claim of citizen centricity in smart city initiatives is abundant, it remains oftentimes ill-defined (Angelidou, 2014; Brandsen et al., 2018; Castelnovo, 2019). Terms such as participatory urban development, co-creation and co-production, open government and crowdsourcing are oftentimes used interchangeably. The neglect of a sound conceptualization of co*-principles leads to placebo involvements that fail to empower citizens, meaningfully collect diverse perspectives and sets of knowledge, and redistribute decisive power. Far too often, citizens are seen as data carriers and input-givers rather than given the position to actually hold power and decide on the shape and outcome of a service (Castelnovo, 2019). "Their 'participation' does not come with any form of actual (decision-making) power or influence" (Leclercq & Rijshouwer, 2022, 3). Another source of defective functions lays in the division of smart city protagonists, especially the practitioners and the critical scholars – the first developing and implementing smart city technology, focusing on potential benefits but with oftentimes little critical reflection on their wider consequences, the ladder offering critique without providing constructive feedback (Kitchin, 2016). These particular challenges, paired with a growing rhetoric of participatory culture in smart cities, run the risk of disenfranchising citizens of their Digital Right to The City[2] (Leclercq & Rijshouwer, 2022) – their right to shaping the city according to their needs and concerns, the right to participate in processes of urban planning and decision-making, and their right to citizen's self-organization (Brenner et al., 2012; D. Harvey, 2003; Foth et al., 2015; Leclercq & Rijshouwer, 2022; Lefebvre et al., 2016; Morozov & Bria, 2017).

By disregarding the coming-into-being of urban technologies, participatory digital urbanism misses the opportunity to engage with the wider implications of participatory processes within socio-technical systems, failing to meaningfully address its performativity and constructedness, and to transform scientific, democratic, and political orders (Chilvers & Kearnes, 2020; Felt et al., 2017; Latour, 2007). In conjunction, science and technology scholars (STS) are asked to reflect on the ordering effects of participatory practices in the digital city, and to take responsibility for the possible social and ethical implications of such a practice (Chilvers & Kearnes, 2020). In doing so, they should devise new forms of collective experimentation, curating novel forms of participation that make it possible to articulate expressions of public issues that would otherwise remain under articulated (Chilvers & Kearnes, 2020). This research sets out to critically examine the creation of smart cities and formulating new visions of collaborative smart urbanism that seeks to gain the promises of smart cities while minimizing their perils. It does so by putting the production of digital technology at the core of its research, and aiming for an interdisciplinary approach in the co-creation of the technologies

[2] As conceptualised by Henri Lefebvre (Lefebvre et al., 2016), the Right to the City acknowledges that all inhabitants should have a right to shape the city according to their needs and concerns, the right to appropriate urban space, and the right to participate in processes of urban planning and decision-making. This concept was adapted to the Smart City (Morozov & Bria, 2017; Foth et al., 2015), writing out a new urban and democratic agenda centered around public control, democratic governance, and citizens' self-organization.

that underpin urban collaboration with the aim of transitioning from critique to the 'reframing, reimagining and remaking' (Kitchin, 2016) of the smart city.

1.2 Structure of the thesis

This dissertation examines forms of collaboration in the development and implementation of three digital urban tools in the city of Hamburg, Germany. The research has a cumulative form and consists of a general framework text followed by three published scientific papers, which can be found in the Appendix. This framing text gives an overview on the general research objectives and the major findings. After a short summary of each publication, chapter 1 presents the Main Research Question, the Research Objectives and paper-specific Research Questions addressed in this thesis and in the individual papers. Chapter 2 presents the literature on collaboration in digital cities and introduces the case study in the city of Hamburg, and the research settings within the City Science Lab. The thesis delineates the emergence of participatory practices in urban planning, novel digital and technological approaches within the field, and derives a working definition for co-creation for transformational change that will guide this research. It examines three experimental settings that employ co-creation in digital city research and development projects. Chapter 3 introduces the methodology designed and implemented in the three case studies and the data derived. The results are presented in chapter 4. Chapter 5 concludes by discussing the key findings and limitations, and gives an outlook supporting digital city makers in their efforts of co-creating their digital cities.

Figure 1: Snapshots of collaboration during the piloting of DIPAS (left), the co-creation workshops with migrants in MICADO (center) and the co-modelling experiment with stakeholders in CUT.

1.3 Publication overview

In the time this dissertation comprises, I published a variety of articles. Three of them are double blind peer-reviewed papers that are presented here as part of this compilation, while the others will be mentioned as further resources within the text, such as Thoneick, Degkwitz, et al., (2021), Lieven et al. (2021), and Ziehl et al. (2023). All three papers published within this dissertation project examine the development of urban collaboration tools and apply participatory and co-creative methodologies

in the development and implementation process. The three case studies had individual research goals differing from the overarching research objectives, they had different funding structures and organizational stakeholders, yet they all were connected in one form or another to my research at the City Science Lab, a research lab at the Hafencity University Hamburg (see chapter 2.2).

The case studies are:

- the GIS-based Digital Participation System (DIPAS)
- a digital service in form of the website and mobile application for the integration of migrants and refugees (MICADO)
- the Digital Urban Twin project connecting different data sets and digital platforms in digital city models (CUT)

A summary of each of the publications is given in the following subchapters.

1.3.1 Paper I: Integrating Public Participation in the Digital City

Citizen participation in urban planning is seen as an instrument to redistribute power, giving citizens a say in their cities, and reducing political apathy (Healy, 2003). Under the ongoing digitalization, administrations and officials have increasingly shifted their participation efforts from conventional towards digital tools. Two major challenges arise under this new e-participation paradigm: the analysis of increasing amounts of participation data and the media break[3] between conventional participation procedures and digital procedures. In the DIPAS system, these issues are addressed with an integrated map-based participation tool bridging analogue and digital participation. This is done by integrating a physical workshop tool and an online participation tool, utilizing georeferenced urban data, digital maps, and 3D models as well as an interface to collect citizen's feedback (Lieven et al., 2021). A digital interface can be operated through physical tools: citizens can thus participate either online, from a remote desktop or smartphone, or on-site, in participatory events.

Thoneick (2021) evaluates the impact of DIPAS and examines the added value of the integration of online and onsite participation. By doing so, it challenges conventional evaluation of participation using Arnstein's aforementioned Participation Ladder (Arnstein, 1969). Expanding on Fung's (2006) Democracy Cube, a three-dimensional analysis tool is introduced to evaluate and analyse concrete values of participation: the selection of participants, the modes of communication and decision-making, and the extent of authority and power deriving from the participation process. The paper examines these aspects using data collected in interviews and usability studies.

The comparison has shown that DIPAS as an integrated procedure combines the benefit of both, online and analogue approaches. By allowing a higher inclusivity through participation via the online contribution tool, and at the same time enabling collaboration through the use of the digital workshop tool, DIPAS allows for a more diverse set of commentaries, ideas and remarks with a higher quality of content. This has implications for the political legitimacy of the participation procedure. As results of the participation process and individual comments are publicly accessible, DIPAS provides a higher transparency, partly handing over the supervision of decision making. Questions remain regarding the

[3] An example for a media break between a digital and a physical process is when a digital document has to be printed and processed manually instead of digitally.

integration of the results collected in DIPAS into formal planning routines and increasing the diversity of participants. The findings enrich the scientific discourse around digital participation by making an argument for a more qualitative evaluation of participation. It showed that digital participation can increase the collaboration between participants, the importance of facilitation during the engagement with digital tools, and the importance of the contextual setting in which the participation takes place, as this heavily restricts or enables the authority a process develops. It also highlights the importance of integrating these data-sets into formal planning procedures.

1.3.2 Paper II: Demand Analysis for Digital Tools through Co-Creation

Migration is a constituting element of urban reality and thus an integrative part of urban development, bringing diversity, new perspectives and impulses to cities (Cranston 2017; Massey, 1991; Saunders, 2011; Yildiz, 2013). However, there exists a gap between the concept of Migration and integration into cities, and the daily lived experience of migrants in cities. The gap between the conceptual and the factual urban is the focus for Thoneick, Malchow, et al. (2021). The paper closes the gap between the quantitative body of work analyzing societal border regimes, identity politic and policy frameworks, and the qualitative body of work enlightening everyday practices of migrants during arrival procedures. It does so by analyzing data derived in the MICADO Project, which aimed at providing a technical solution, more precisely a mobile application and browser applications, for user groups, making arrival and participation processes more efficient. The overall project goal was to create a tool for the arrival process of migrants that will be integrated into existing structures. To ground the technical development on a scientific base, the project group went through a thorough phase of fundamental research, first through an extensive literature research and then by conducting a series of co-creation workshops with the user groups migrants ans refugees, civil society organization and members of public administration in the field of migrant integration.

By comparing two bodies of data derived from the literature research and the co-creation studies, Thoneick, Malchow, et al. (2021) conducted a secondary data analysis. This was done to examine the benefits of combining a quantitative analysis with qualitative data from co-creation in order to shed light on complex arrival procedures. It did so through the analysis of three aspects: research field, scope and specificity vs generality. The paper offers insights into the gaps that open up in the interspaces of migration policies and arrival processes. Those consist of but are not limited to a mismatch between the availability of and actual access to crucial information. By shedding light on these characteristic gaps and the strategies triggered by them, Thoneick, Malchow, et al. (2021) emphasises the significance of an integrated investigation into complex urban arrival systems. By discussing the combination of both qualitative and quantitative methodologies, this paper concludes that research in the complex field of migration and integration benefits from an integrated approach that looks at quantitative data and policy levels as well as tacit knowledge and everyday practices. The paper is a valuable contribution to the oftentimes claimed benefit of participation, namely to make visible latent and implicit knowledge, especially when it comes to marginalised communities and their tacit knowledge and everyday practices.

1.3.3 Paper III: Modelling Complex Challenges in a Digital Urban Twin

In recent years, Digital Urban Twins have become crucial components of digital cities. In the Connected Urban Twin project (CUT), the cities of Hamburg, Leipzig and Munich are collaborating to establish a modular digital infrastructure that enables the creation of what-if scenarios to enhance

governance processes (Schubbe, 2023). As part of this endeavor, a series of real-world experiments are being conducted to test technologies with a diverse range of stakeholders (Herzog, 2023; Ziehl et al., 2023).

These practices involve modelling the city into a digital replica. Models are powerful tools to enhance and discipline our thinking about complex matters, as they simplified representation of reality (van Bruggen et al., 2019). The question arises, which data and knowledge, and whose perspectives, are included in these models, and whether the co-creative modelling of a digital urban twin allows for diverse perspectives to be integrated. Thoneick (2023) describes the design and implementation of a participatory modelling framework during a real world experiment, putting co-creation at the centre of the development process of the digital urban twin in Hamburg. The case study involves representatives from public administration, civil society, and the private sector, who actively participate in co-creation workshops. The goal is to design a model addressing climate protection and social equity, specifically gentrification processes in Hamburg triggered by climate protection measures.

The paper expands on previous analytical frameworks and focuses on four conditions of co-creation: agents, practices, agency, and reflexivity. By analyzing data derived from participatory observations, interviews and reflexion discussions, the paper outlines how the four dimensions of co-creation are manifested in the twinning case study. They indicate that a careful design of co-creative twinning workshops and consideration in selecting stakeholders is required to open up space for communication and acting together, allowing for the emergence of trust, transparency and agency. The research shows that complex models for digital urban twins can indeed be modelled co-creatively. The four dimensions of co-creative twinning have been helpful in analyzing the dimensions of co-creation, and the research describes emerging practices and requirements for stakeholder involvement as well as potentials of co-creative twinning.

1.4 Research objectives and research questions

In order to put the contents of the three individual papers into an overall context, this chapter will outline an overarching research objective and present general research questions concerning the three publications in the Appendix. The guiding research interest of this thesis was to understand and qualify pathways for co-creation in the digital city by studying concrete case studies, and to develop novel approaches for the co-creation of the technologies for urban co-creation with the goal of transformational change in the systems of digital participation within the city of Hamburg. This transformational research agenda includes the establishment of new stakeholder constellations and the creation of novel ways of acting with and through digital tools for co-creation, allowing stakeholders to critically reflect on current system pathways and to improve their understanding of requirements for sustainable change.

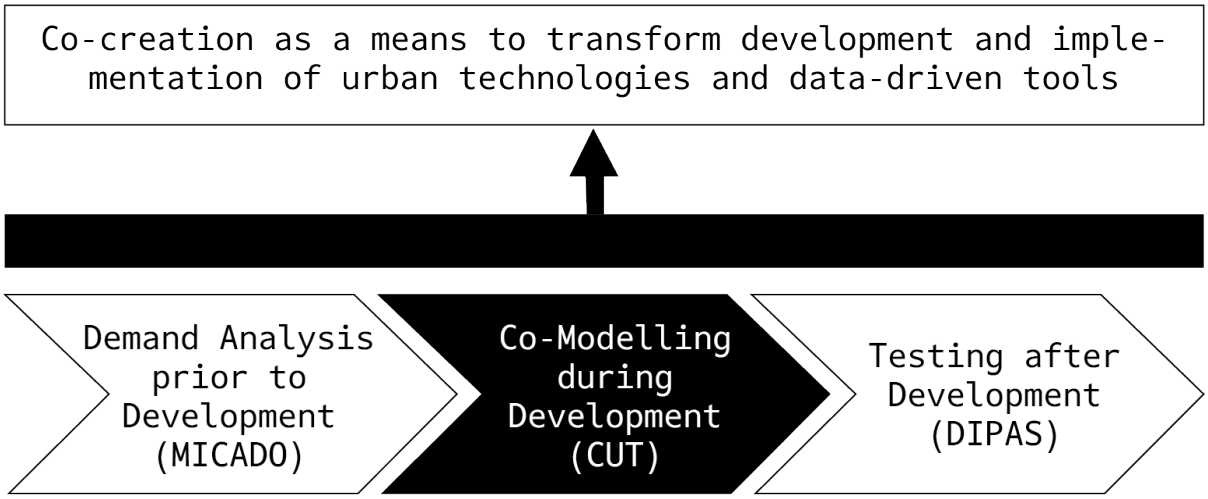

Figure 2: The different phases of co-creation during the development of urban technologies as examined in the three papers of this dissertation. This figure disregards the chronological order of these papers and organises them in their logical order.

To arrive there, the research had to understand how and to what effect development processes[4] within digital cities can be subject to co-creative efforts. In doing so, the thesis examined selection processes of participants, the modes of acting and communicating within a co-creative procedure, and the agency they developed in terms of critical thinking and knowledge reconfiguration. Approaching these questions, the research examined co-creation at different stages of a digital development process:

(1) Paper I examined the participation of citizens **after** the development process for a participatory platform had been concluded, by conducting Usability and User Experience Studies and testing the platform during Piloting Events;
(2) Paper II designed, employed and evaluated a co-creation methodology that had been used for the Demands and Requirements Analysis **prior** to the development of a mobile app and website;

[4] In this dissertation, for brevity purposes, the word development will stand for digital and software development.

(3) Paper III designed, conducted and analysed a co-modelling approach within a Digital Urban Twin Framework, testing novel approaches to co-creatively design a digital urban model **during** the development phase.

Through the analysis of tools and methodologies within the three case studies, valuable knowledge on design principles for co-creation in the digital city could be derived. The Main Research Question (MRQ) for this dissertation is:

How can participatory and co-creative principles be employed in the development of urban technologies and data-driven tools, and how does their implementation transform perspectives, knowledge, and agency within the digital city?

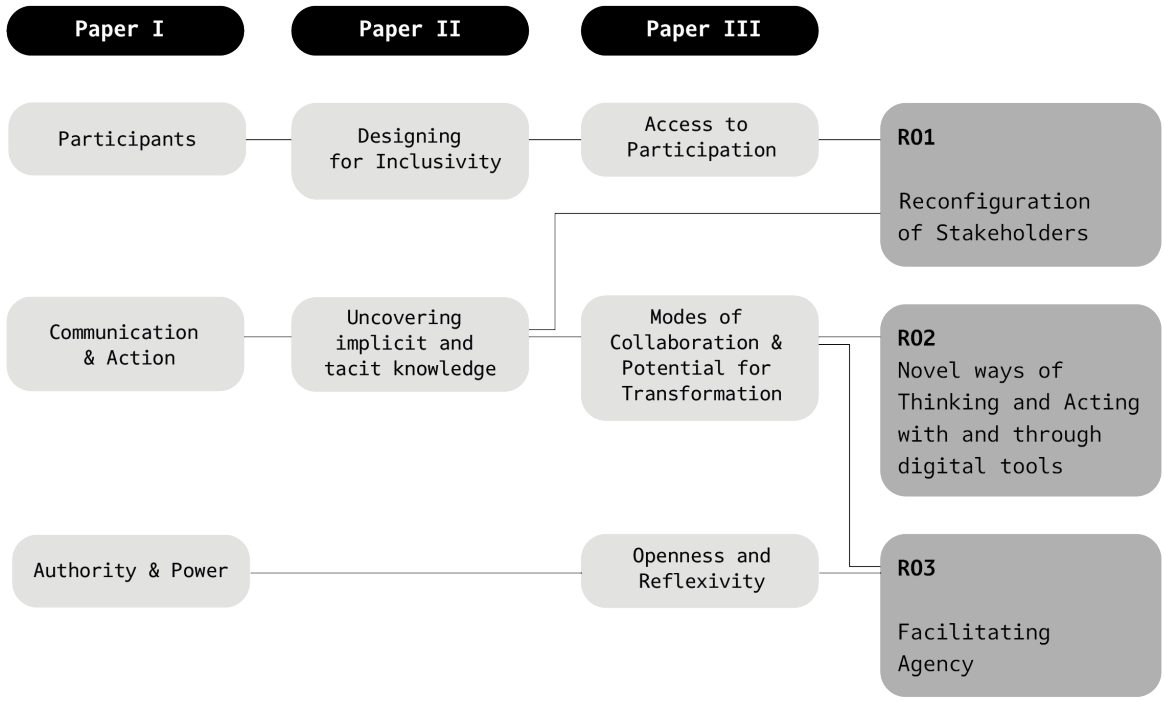

Figure 3: Paper-specific Research Questions in relation to the Research Objectives.

1.4.1 Research Objectives

Each of the three papers had individual research questions directed at the respective project contexts. However, they all examined collaborative efforts in the digital city and their transformational potential. The common Research Objectives (RO) can be deduced, spanning over the research in total.

RO1 – Reconfiguration of Stakeholders
To assess how a co-creative practice within the digital city invites and includes a higher diversity of stakeholders, and if that concludes in a higher quality of results.

RO2 – Novel ways of Thinking and Acting with and through digital tools
To describe how a co-creative practice enables novel ways of thinking and acting with and through digital technologies and data driven tools.

RO3 – Facilitating Agency
To illuminate how a co-creative practice enables sharing of decisional power and ownership between the stakeholders of the Digital City, and how this enables stakeholders to critically reflect on system pathways and improve the requirements for sustainable change.

In completing these research objectives, this thesis derives valuable knowledge for practitioners and researchers of the Digital City. Deriving design principles from these findings helps city-makers design and think about their co-creative efforts in a transformative way.

1.4.2 Research Questions

The Research Objectives presented above extend over all three papers published in the context of this thesis. To enable a cross-paper analysis of the Research Objectives, novel paper-specific Research Questions (RQ) will be deduced for this framework paper. These RQ help guide the analysis of the three papers and put them into a meaningful relation, further elaborating and deepening the understanding of the quality of participatory and co-creative principles in digital city strategies. These paper-specific Research Questions are formulated in the following subsections and the answers to them are presented in chapter 4.

Values of Participation and their Building Blocks
In Paper I, the integrated public participation tool DIPAS was compared with online and offsite participation procedures. The goal was to understand whether an integration of participation in physical spaces with online participation tools allowed for a higher inclusivity and more specific results, combining the benefits of both approaches. In order to shed light on the RO1, Reconfiguration of Stakeholders and Knowledge, three main axes were defined along which the analysis was guided: the selection of participants, the modes of communication, and the extent of authority and power emerging from the participation procedure. The following paper-specific Research Questions are helpful in deriving understandings for the overarching research objectives of this thesis:

RQ 1.1 How can e-participation lower thresholds for participation and broaden outreach in absolute numbers as well as inclusiveness of otherwise difficult-to-reach communities?

RQ 1.2 Are preferences of citizens explored, developed, and possibly transformed during a collective deliberation procedure?

RQ1.3 How are citizen commentaries transmitted to planners or results of the participation procedure integrated into formal planning systems?

Including marginalised communities in co-creation in Digital Cities
Paper II made an argument for the integration of quantitative and qualitative research methods in complex questions of arrival procedures and integration processes. It examined the development of an app and a website to facilitate arrival procedures in MICADO by co-creating the requirements

together with marginalised communities. In order to enlighten the benefits and challenges of co-creation procedures, the following research questions will guide the analysis:

RQ 2.1 How can marginalised communities be invited to co-creative efforts in digital cities?

RQ 2.2 How does co-creation lead to a reconfiguration of knowledge?

Developing Agency by co-modelling Urban Twins

While Paper I and Paper II focused on participation after the development of a participation tool and co-creation before the start of development, Paper III focused on the actual process of coding and development of a digital urban twin. In answering the Research Objectives, the following questions will guide my analysis of the paper:

RQ 3.1 What are the conditions for and the access to participation in a co-modelling approach?

RQ 3.2 Which novel practices of acting with and through digital tools emerge, and how do they support transformation?

RQ 3.3 How is the process of co-creation open to emergence and uncertainties?

2 Literature and Case Studies

To provide an overview of co-creation and participatory principles in digital cities, this chapter elaborates on the genesis of participation in urban planning and contemporary forms of it. There are two fields of research and practice that offer valuable knowledge to understand co-creation in the digital city, and both have been influential on my research: participatory urbanism and Science and Technology Studies (particularly those researchers engaging with participatory design in software development). Both will be outlined in the first part of this chapter. In the second part, the field of study is presented.

2.1 Principles of Collaboration

2.1.1 Participatory Urbanism and Co-creation in the Digital City

The participation of citizens in urban planning processes has been widely discussed and documented ever since Jane Jacobs' birth of the *democratic urban planning* in 1961 (Jacobs, 1992). The turn from top-down large-scale strategic planning developments towards empowered citizen action has had an impact on planning strategies worldwide. In her typology of citizen participation, Sherry Arnstein famously characterised the diverging roles of participatory processes, ranging from *manipulation, therapy* (of the public on the rungs of Nonparticipation), through *informing, consulting,* and *placation (*past the degrees of tokenism), towards the degrees of citizen power, namely *partnership, delegated power,* and *citizen control* (Arnstein, 1969). The perception was that citizens should have a say in how their city is governed, which led to a wide array of collaborative planning practices that aimed at sharing power and enabling all stakeholders to have a voice (Healey, 1997).

Participatory literature puts specific emphasis on communicative elements, shifting from strictly analytical approaches in urban planning towards those including deliberation, local expertise and implicit knowledge (Fischer & Gottweis, 2014), recognising and emphasising a diversity of meanings, knowledge, and interests within local communities needed for the multifaceted challenges of contemporary governance (Fung, 2006; Silva, 2012). Participatory planning is now being tested in a variety of political and social frameworks, such as in France, Hungary, Sweden and Croatia (Randma-Liiv & Lember, 2022), in Zimbabwe, South Africa and Kenya (Horn et al., 2018), in Bangladesh (Panday & Chowdhury, 2020), in Brazil (Araújo et al., 2022), and specifically in Hamburg (Hälker et al., 2018; López Baeza et al., 2020; Thoneick 2021; Ziehl, 2021). Many cities have successfully integrated citizen participation and co-creation within their planning processes, and an extensive body of literature emphasises its benefits. As part of political decision-making in urban planning, citizen participation is seen as an instrument to enhance the effectiveness and efficiency of public policy making (Brandsen et al., 2018; Ostrom, 1996), redistribute power, and include citizens in the process of determining the future of their cities (Bovaird, 2007), give vulnerable groups access to public services (Van Praag, 2021), and imbue the democratic processes with more transparency, thus decreasing political apathy and building trust (Noveck, 2015; Randma-Liiv & Lember, 2022).

The ongoing rapid digitalization of everyday life continuously transforms public participation, opening new possibilities for engagement of multiple actors in decision-making processes and

facilitating e-participation through Geo-web tools and new methods of engagement (Silva, 2022). Participatory Mapping tools using geospatial data allow communities' viewpoints to be represented and thus appreciated by governments, corporations, and the public (Burnett et al., 2023). GPS-enabled mobile devices are used to map location data in the field and visualise in real-time (Hennig et al., 2023). Finally, digital community engagement platforms enable the creation of systematic and comprehensive participatory platform GIS data collections (PPGIS), and enable the analysis and reporting of data and activities (Kyttä et al., 2023).

While participatory principles are oftentimes focused on deliberative practices, more user-centered approaches such as co-creation, where the user is seen as an expert of her experience (Stembert, 2017), have found their way into design theory and software development concepts. During the process of co-creation, collaborators are involved in all stages of the research and development of new ideas or products (Van Praag, 2021), jointly defining the problem and creating the solution, a process through which latent knowledge becomes tangible and produces insights needed to develop requirements for system architectures (Stembert, 2017). The involvement of participants ideally reaches all stages of design or research: "from developing research questions to formulating theories and identifying (new) methods, in order to develop and provide feedback on new tools and products, or generate inspiration for new ideas" (Van Praag, 2021, 18). This approach is fit to ensure the usability of developed products and the uptake of the solutions, but more importantly it is fit to enable systemic transformation. "In a methodological view, the above consideration implies a transformation from professional problem-solving expertise to participative projects, directed by designers, and finally towards collaborative/collective/communicative action, possibly facilitated by designers" (Jonas, 2015, 127). This has an impact also on the designer and researcher, who are, rather than experts in a field, facilitatord enabling others to share their knowledge.

2.1.2 (Transformative Research in) Science and Technology Studies

The field of Science and Technology Studies (STS) offers valuable analytical tools for comprehending the collaborative creation of technologies and their subsequent impacts. A significant portion of research within Participatory Design and Computer Supported Cooperative Work focuses on the design of computer-based systems, utilizing interdisciplinary teams and embracing rapid prototyping approaches. Originally, this field emerged as a response to the disruptive nature of technological innovations in private sector work environments, with the goal of empowering workers to exert more control over their work processes (Kensing & Blomberg, 1998; Zimmerman & Forlizzi, 2014). Concurrently, user-centered design principles and Design Thinking have evolved within the realm of Human-Computer Interaction, emphasizing iterative design and development processes that prioritise user needs to ensure product usability and adoption (Ghaoui, 2006; Stembert, 2017). While these practices often center on prototyping, seldom going beyond the early analysis and design activities, some have actively engaged users throughout the entire development process to create adaptable software products. Examples include the Cooperative Experimental System Design (CESD) approach (Grønbæk et al., 1997, 2002) and the Participatory Modelling (PM) Community (Abrami et al., 2021). The latter notably involves non-scientist stakeholders from the early stages of modeling, during preparation and organization, up to follow-up stages such as dissemination and evaluation. A rather new addition to the field has been published by van Langen et al (2023) in their "Participatory Design for Participatory Systems" (PDPS), helping organisations to collectively build sustainable relationships. Van Langen et al. point to the same effort this thesis is aiming at: collaboratively designing the systems for collaboration in the digital city.

Despite the well-established nature of the CESD and PM approaches in Human-Computer Interaction and socio-ecological settings, there remains a scarcity of case studies applying these methods to digital urbanism. Although there is a growing body of literature advocating for a participatory approach to the Digital City, participatory digital urbanism often remains confined to the design analysis phase before development, or to the collaborative delivery of services and products post-development, and frequent encounters challenges when seeking integration into local government procedures (F. Harvey et al., 2022).

By primarily focusing on the design of urban technologies and not the process of developing these tools, participatory digital urbanism overlooks the broader implications of participatory processes within socio-technical systems. This oversight hinders a meaningful exploration of its performativity and constructed nature, and misses the potential to transform scientific, democratic, and political frameworks (Chilvers & Kearnes, 2020; Felt et al., 2017; Latour, 2007). Transformation design, as Jonas (2015) cites the British Design Council, is "a human-centred, interdisciplinary process that seeks to create desirable and sustainable changes in behaviour and form – of individuals, systems and organizations – often for socially progressive ends" (Jonas, 2015, 116). In a world undergoing a continuous globalization and rapid digitalization of everyday life, there is a fundamental change in how we generate knowledge and communicate, and thus, how we collaborate. This is at the heart of transformative practice; it not only pursues the goal of learning together and optimizing processes, but also aims at changing the real conditions in a constructive and sustainable matter (Weber & Ziemer, 2022; Ziehl et al., 2023). New stakeholder constellations have to be established, allowing them to collaboratively search for alternative futures of their cities, and enabling a 'transformative literacy' (Schneidewind, 2014) that puts civil society, and political and economic actors in the place where they can improve the requirements for sustainable change. A transformative participatory and collaborative practice "engages participants in a continuous, dynamic exploration of reality, which 'transforms people's reality and their sense of it', empowering them to take ownership of it" (van Bruggen et al., 2019, 9). A practice can be viewed as being transformative when it supports participants to reflect critically on current system pathways and formulate transformative policy pathways and action plans (van Bruggen et al., 2019, 3). This is especially important when designing the digital city. As tools such as Digital Urban Twins rely on modelling the real world in a digital replica, these models are powerful tools to enhance and discipline our thinking about complex matters, as they simplify reality and rely heavily on the assumptions on which they are built (Batty, 2018; van Bruggen et al., 2019). By building models together, the process of transformative change is supported. Participatory modelling not only is employed to fit a purpose, but is also governed by a different concept of expert knowledge and power; it thus continuously builds capacity within individuals, communities and institutions within an evolving framework (van Bruggen et al., 2019). This focus on transformative change is also what preserves co-creation from staying behind its promises of transforming society, governance, and knowledge production (Turnhout et al., 2020).

This thesis brings the research in the Co-creation of the Digital City a step forward by examining the development processes of three concrete and applied urban technologies, a participation platform, an app and a co-modelling platform within a Digital Twin framework, By designing and implementing co-creation methodologies during the building of the tools and critically reflecting on them, this research dissects co-creation of the digital city in terms of the actors involved, new practices emerging, and their suitability to enable transformative change in terms of enabling agency, ownership, and a sharing of decisive power within actors of the digital city. It distills learning on how to design processes that use co-creation for the transformation towards sustainable cities and proposes several ideas in moving forward, giving digital city makers valuable methods into their hands.

2.2 Objects of the research

2.2.1 The Digital City of Hamburg

Given its existing digital infrastructure, open data laws, and ongoing digitalisation initiatives, Hamburg is a suitable location to research co-creation efforts in digital cities. For several years, it ranked highest among German smart cities, as indicated by a 2021 index (Statista, 2023a). With its population size of 1.89 million (Statista, 2023b) and commitment to achieving carbon neutrality by 2045 (Hamburger Senat, 2022), Hamburg provides an ideal context for investigation of transformative digital strategies. With a strong focus on collaboration, its Digital Strategy aims at social, economic, and societal progress (*Digitalstrategie Für Hamburg*, 2020). The urban data platform acts as one of the backbones of the digitalisation, providing access to urban data sets, and technologically linking the city's systems and databases (*Digitalstrategie Für Hamburg*, 2020). This forms the basis of development for many services and new developments (Thoneick, Degkwitz, et al., 2021).

2.2.2 City Science Lab

The City Science Lab (CSL) at HafenCity University in Hamburg was initiated in 2015 as part of the 2015 Digital City strategy in a collaboration with the MIT Media Lab. It is a scientific research unit examining the transformation of cities in the context of digitalisation by developing innovative tools and services and providing scientific support und knowledge diffusion. Since that time, the CSL has been engaged in a variety of interdisciplinary, cross-ministerial, and cross-departmental projects, involving multiple stakeholders and actors within the city of Hamburg. The CSL is an important actor in the creation of innovative digital urban projects, and envisions the city of Hamburg as a 'living lab', collaborating with the city's public administration to develop and test digital urban technologies. It is researching and developing new approaches in the fields of urban and social planning, migration, and mobility, and each of the applied project engages with the three core research topics: multi-stakeholder collaboration, data and modelling, data storytelling and data visualisation (Weber & Ziemer, 2022).

Within these collaborative projects, the CSL has developed 'CityScopes' on the basis of previous work by the MIT Media Lab City Science Group (Alonso et al., 2018): interactive and data based city models for developing future scenarios of the city, modeling and simulation. Other tools are open data hubs, data governance systems and participation platforms (Degkwitz et al., 2021).

Since 2020, the CSL has been engaged with UN Habitat to establish the first Innovation and Technology Lab of the United Nations. The "United Nations Technology Accelerator for Cities" (UNITAC) is a project that addresses urban challenges in the global south with the help of technological applications. Within the people-centered smart cities approach of UN Habitat, interdisciplinary teams develop services for experts and citizens alike.[5]

[5] More on UNITAC projects on https://unitac.un.org/our-work

2.2.3 Projects

The CSL has engaged in a variety of applied interdisciplinary research and development projects[6] , ranging from the topics of social planning to migration and mobility. As this dissertation focuses its research on three of these projects, these will be shortly introduced here.

The **Digital Participation System** (DIPAS) was developed between 2017 and 2020. It connected the exisiting online participation tool of Hamburg with the CityScopes developed in the CSL into an integrated digital system for citizen participation. Through the system, citizens can engage with planning proposals from home, mobile, or in participation events. There, they can access digital maps, aerial images, 3D models, and geodata and give localised feedback for urban development projects (Lieven et al., 2021). The project was a collaboration between the Department of Urban Development and Housing (BSW), the State Office for Geoinformation and Surveying (LGV), and the CSL. DIPAS was the first media-independent application that has been developed for informal citizen participation in planning projects. It was published as open source and can be transferred into other urban contexts[7]. Within the cooperation project, the CSL was responsible for scientific support, knowledge processing and the development of analysis scenarios. As a researcher in the project, my role was the synthesis research, the design and development of a research methodology for usability and user experience studies, the scientific evaluation of usability and user experience studies and of several piloting events, and the translation of the findings from these interactions into concrete technological development needs.

The **Migrant Integration Cockpits and Dashboards** (MICADO) project aimed at developing a platform and mobile app to facilitate the arrival process of migrants and refugees and improving communication between migrants, civil society organizations and public administration. The envisioned solution was to establish effective channels for communication and data exchange and provide valuable information and integration services to all three target groups via customised user interfaces. For this, MICADO created data dashboards and cockpits: precisely designed information displays respective interactive applications that make complex information understandable, easy-to-use, and more valuable for end-users. Co-creation was an important aspect in the project. In order to create attractive and useful data services, MICADO aimed to involve all relevant stakeholders (especially migrants themselves) in the design and development of the solution. With co-creative formats that engaged authorities, civil society, and migrants, the stakeholder groups engaged with the project throughout the design and development process. The project received funding from the European Commission in the framework of the Horizon 2020 programme and involved partners in Antwerp, Bologna, Hamburg, Madrid and Vienna. It ran from 2019 to 2022 and included co-creation workshops with migrants and refugees. My role in the project was to support the fundamental research and employ the co-creation methodologies in localised workshops with the three target groups.[8]

The **Connected Urban Twins – Urban Data Platforms and Digital Twins for Integrated Urban Development** (CUT) project was launched in 2021 and is ongoing. The project received substantial

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[6] For a complete overview on CSL projects visit https://www.citysciencelab.hamburg/projects

[7] More infos on the DIPAS projects and relevant contacts can be found on https://www.dipas.org/

[8] More infos on the MICADO project and relevant contacts can be found on https://www.micadoproject.eu/

funding from the Federal Ministry for Housing, Urban Development and Building (BMWSB) and stands as one of Germany's largest smart city projects. During the five-year project runtime, the three partner cities of Hamburg, Leipzig, and Munich have been working together to advance the development of data-driven urban twins for cities and municipalities. These modular systems have different building blocks that can be assembled in different combinations for use in integrated urban development. The goal is to produce digital representations of cities that can be used for the creation of what-if-scenarios and enhance government processes (Schubbe, 2023). Through the cooperation of the three cities under the leadership of Hamburg, common standards are to be developed for this purpose that can also be replicated and applied across metropolitan regions and other cities on an international scale[9]. In the project, digital twins are being developed and tested on the basis of concrete use cases for integrated urban development. Cooperation between public and private actors is promoted, and citizens are involved as co-researcher. As part of this endeavour, a series of real-world experiments are being conducted to test technologies with a diverse range of stakeholders. My role in the project was the development of use cases for these real-world experiments, and I have been involved as a facilitator in the experiments, engaging with stakeholders on the piloting of the digital tools and reflecting on the benefits and challenges as well as translating findings into technical development needs.

[9] More information on the CUT project to be found on https://www.connectedurbantwins.de/en/

3 Methodology

This chapter gives an introduction into the methodologies which were applied in the three papers published within this dissertation project. They all describe participatory or co-creative principles that were employed at different stages of the development process of the respective tools – before the start of development, during development, and after completion of the development. These collaborative practices had different goals and shall be connected in this framework paper. The principles are described in the subsequent sections in the following order:

1) In Paper I, the impact of participation through the integrated DIPAS tool is evaluated and compared to other forms of citizen participation. The analysis happens along three axes: the selection of participants, mode of communication, and agency and power. The research here focuses on participatory events after the completion of development.
2) In Paper II, qualitative data deriving from co-creation workshops is compared to data from a quantitative literature analysis and analyzed regarding their ability to provide valuable knowledge on formalised systems and informal daily practices. In this case, co-creation happened prior to technical development, as a means to involve experts early for their input on demands, ideas, and requirements for a digital or data-driven tool.
3) Paper III moves co-creation to the center of the development process. In analyzing a complex co-modelling process, it sheds light on co-creation during the process of building a digital tool. It elevates citizens to partners in the process and analyzes inhowfar co-creating the co-production tools allows urban actors to collaboratively govern frameworks of implementation, produce transparency in code for urban technologies, and answer to urban complexities.

These three research papers provide a valuable evaluation of co-creation in different phases of urban tech development projects. Combined, they represent means to improve smart city technology development and implementation and shed light on the different requirements needed for opening development processes for citizens and other stakeholders.

3.1 Usability / User Experience Study and the Participation Cube

Since the emergence of public participation in Urban Planning during the 1960s, the involvement of citizens in the plans of their cities has been a paradigm in many urban strategies. Criticism has pointed to its limits, when participation is used as a tool for consensus building, producing approval through placebo participation procedures, instrumentalising citizens without sharing authority or power (Arnstein, 1969; Miessen, 2012; Mouffe, 2013; Rancière, 2008; Turnhout et al., 2020). This paper aimed at elaborating on concrete values of participation in order to make a meaningful contribution to the qualitative effect of participation in urban planning. It did so by applying an alteration of Archon Fung's Democracy Cube (2006) – the Participation Cube (Thoneick, 2021) – a theoretical model aligning three features of participation along the axes of a three-dimensional cube. Its features are (1) selection of participants, (2) modes of communication, and (3) the extent of authority and power. This model was applied to the examination of the DIPAS development process.

In the first dimension, **selection of participants**, the threshold for participation is addressed, asking, who is included in the participation procedure. As high thresholds in citizen participation pose the threat of excluding already marginalised groups such as migrants and people with lower sociocultural

resources, these processes run the risk of pushing those communities even further to the edge of the political discourse (Kast, 2008; *Handbuch Zur Partizipation*, 2012). The study examines this topic by asking who is eligible to participate in a process facilitated by the DIPAS tool, how onboarding of participants is designed, what knowledge and perspectives participants bring to the workshop. In answering these questions, the research scrutinises the inclusiveness of a participation process facilitated by the DIPAS tool.

In the second dimension, **modes of communication**, the study puts a focus on the form of communication and decision making within a participation procedure facilitated by the DIPAS tool. Is participation still limited to conversational modes of collaboration, where participants can express and exchange concerns and preferences, or does the process invite a more deliberative mode of communication, where individual choices can be exchanged and mutual agreements established (Healey, 1997; Granberg & Åström, 2010). This is done by examining whether the process allows for the exploration of citizens' preferences, developing and possibly transforming perspectives and knowledge during the procedure. Characteristics such as the communication during events, connection of relevant stakeholders, and the aggregation of voices are analysed.

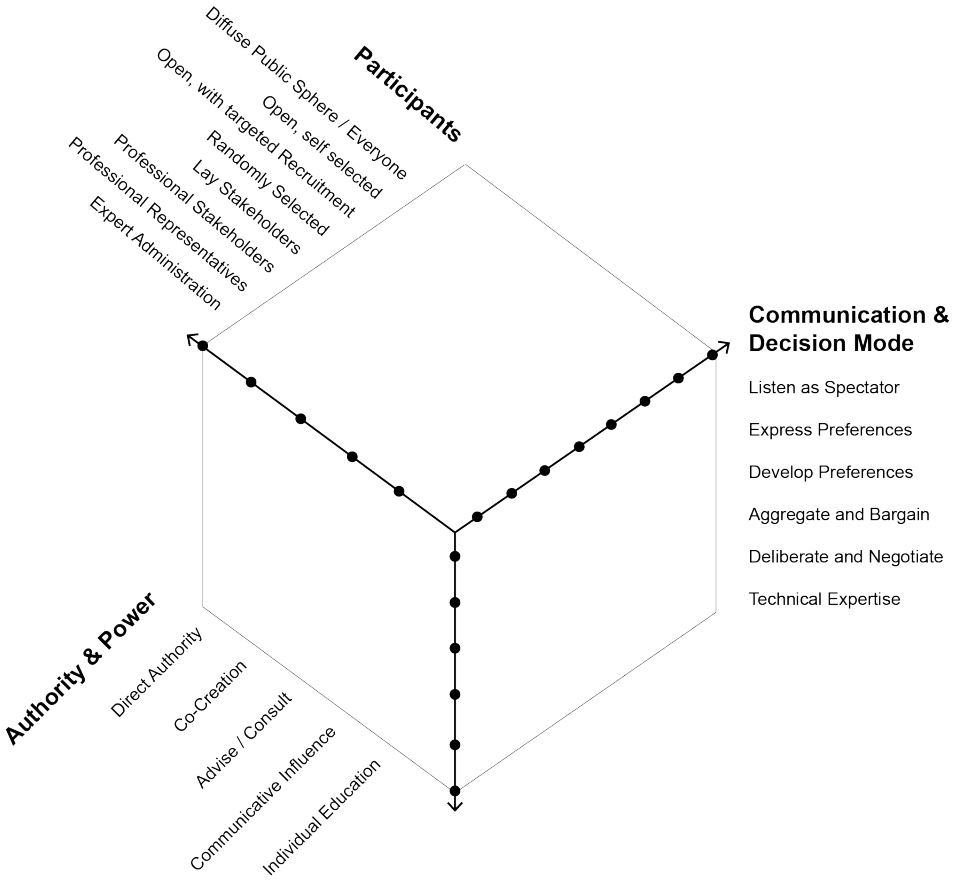

Figure 4: The Participation Cube (Thoneick, 2021).

In the third dimension, **extent of authority and power,** the scope of the participation process and the authority in decision making is evaluated. The extent of how participation procedures are anchored within democratic institutions can limit the unfolding power, which can lead to frustration in the public eye and harm trust in democratic and participatory procedures (*Mehr Partizipation wagen Argumente für eine verstärkte Beteiligung von Kindern und Jugendlichen*, 2010). Specific focus is set on the question of how the process is anchored within democratic structures. Within this feature, the communicative influence and possibilities for decision making are examined, as well as the level of influence on authorities as well as transmission of citizen comments to planners and the integration of the participation into formal planning procedures. This allows comments on the effectiveness as well as the development of agency by citizens within the process.

With the help of the cube, the participation procedure facilitated by the DIPAS tool was analyzed regarding two user groups: planners and citizens. The data was derived from the empirical study accompanying the technical development of the DIPAS system during the project runtime between September 2017 and August 2020. Data on the planner's perspective was collected in a semi-standardised interview with two planners who had previously used the DIPAS tool in a public participation process. The citizen perspective was assessed in two different settings: a focus group setting testing the usability a user experience of the tool, and during piloting workshops in real-world participatory settings. The data was collected in the form of transcribed interviews and participatory observations. All data was coded and analyzed using MaxQDA following the principles of a structured content analysis (Mayring & Fenzl, 2014). This methodology allows for the discovering of latent content, and statistically analyzing qualitative insights.

3.2 Systemic Literature Review and Co-Creation Workshops

The second research paper examines the gap between formalised migration systems and the multitude of micro-practices in complex arrival procedures and integration processes (Breckner, 2018; Saunders, 2011; Terkessidis, 2010). The gap consists of a mismatch between the availability of crucial information for arrival processes and actual access to this information. This paper sheds light on these gaps and the micro-strategies triggered by them, emphasizing the significance of an integrated investigation into complex urban arrival systems. The paper bridges and integrates qualitative and quantitative approaches of knowledge generation, analysing quantitative data and policies as well as tacit knowledge and everyday practices derived from co-creation workshops with migrants and refugees. In doing so, it sheds light on the complexity of arrival procedures and the requirements needed if these processes shall be facilitated through digital tools.

Two datasets were compared in the MICADO research paper through a secondary data analysis. The first is a quantitative data set, derived from a Systematic Literature Review (SLR), the second is a qualitative data set, stemming from observational data and interview transcripts assessed in several co-creation workshops with migrants and refugees.

An SLR is a secondary study of data relating to a specific research question using a well-defined methodology and following specific steps (Ferreira da Silva Barros & Jose da Silva Rodrigues., 2008; Kitchenham & Charters, 2007). In the first year of the MICADO project, an SLR was conducted to provide a framework in the field of migration research and identify gaps that help focus the approach

of MICADO. More specifically, MICADO aimed to obtain a general picture of documents related to the arrival process of migrants, asylum seekers and refugees; study policies within the field of migrant integration as well as their effectiveness, especially policies in the domains of health, housing, education, employment, and participation; and identify individual characteristics and contextual factors positively and negatively affecting integration (Diaz-Chorne et al., 2019). For the SLR, all articles in the database Web of Science from the previous five years were selected, resulting in 176 documents that went into screening for eligibility. 70 papers were selected for the actual SLR, plus six national and local reports. This body of literature was read and analysed according to predefined research questions regarding integration challenges in the domains of education, healthcare, housing, labour and participation. Within a literature reference system, each text was then labelled according to its scope, methodologies and specific characteristics to facilitate the process of analysis.

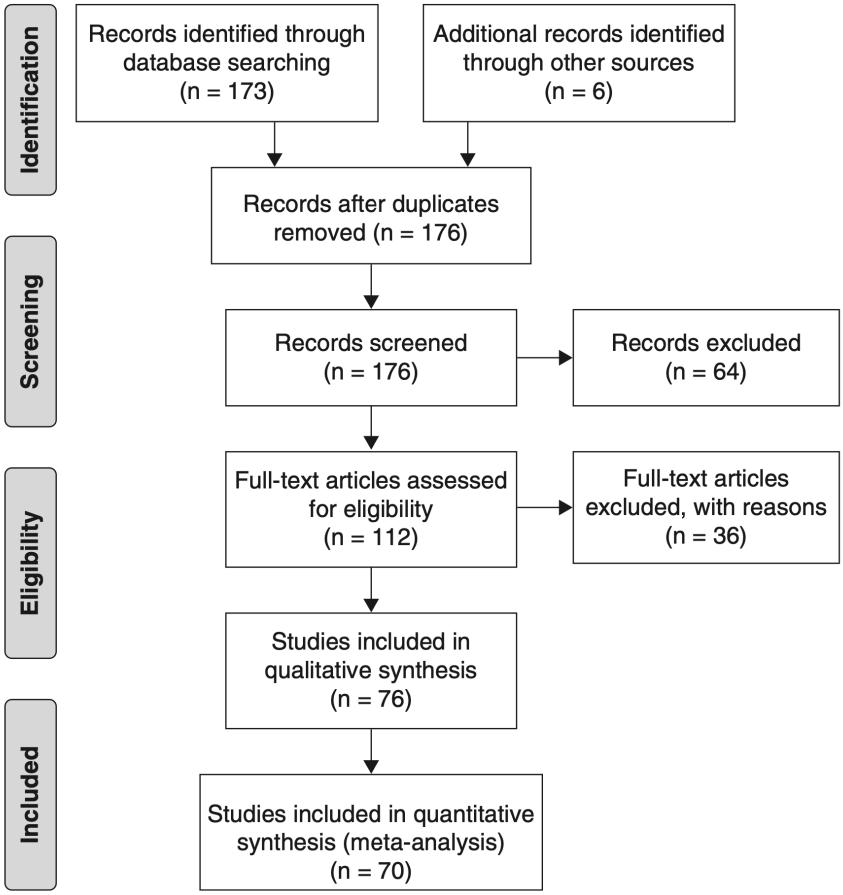

Figure 5: Prism graph of SLR body of literature and filtering process (Diaz-Chorne et al., 2019).

After this SLR and during the first year of the project, co-creation was employed to understand the most pressing needs of two of MICADO's user groups: migrants and representatives of civil society organisations. Over a period of half a year, the project consortium's local groups of Antwerp, Bologna, Hamburg, and Madrid organised several workshops each with participants from the specific target groups. The co-creation in Hamburg took place in a series of five workshops. The invitation to these workshops was extended through NGOs that were already involved in the research project and which distributed the call across their wider networks. Of the 21 participants, 10 were male and 11

were female, aged between 21 and 53 years and coming from different geographic, cultural, and educational backgrounds (Diaz-Chorne et al., 2019). Each workshop consisted of three phases: a warm-up exercise, a board game that asked participants for their experiences and what they had learnt during their migration story in a structured yet open way, and a journey mapping exercise that guided participants to sort their previous answers into structured processes. These workshops lasted three to four hours each and were documented by researchers using structured documentation sheets, which were used as the source for the following data analysis.

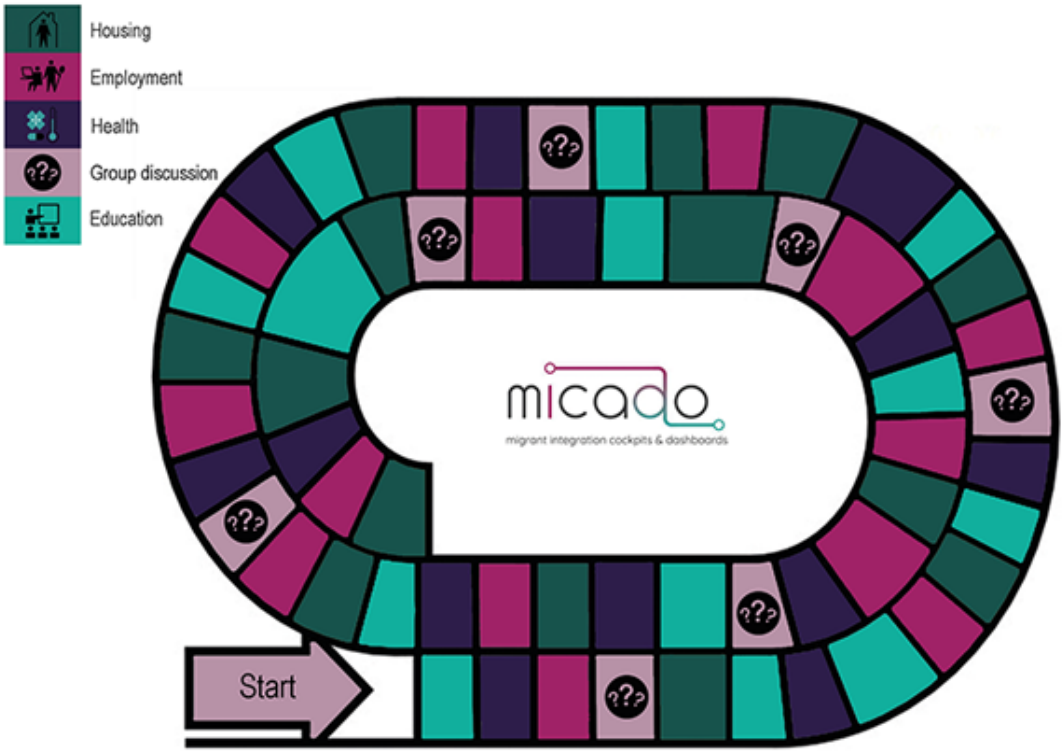

Figure 6: The Micado board game (Source: micadoproject.eu)

Paper 2 compared two datasets according to their meaningfulness for answering a complex research question in the field of urban migration. In order to reach insightful findings, the research followed the approach of comparative analysis described by Morlino (2018). Both datasets sought to understand the challenges and hindrances in arrival and integration procedures. In order to compare these two data sets, a secondary data analysis has been conducted (Heaton, 2008). Paper II compares the two aforementioned data sets, systematic literature review data (Set 1) and co-creation data (Set 2). Within these sets, the following aspects were identified for comparison: research field (Aspect A), scope (Aspect B), and specificity versus generality (Aspect C). By coding the two datasets according to these aspects, the comparison was made possible. Having analyzed these codes, statements were made about the level of detail in which the topics are covered and the regional scope of a study to help understand the specificity and generality of the research results. The comparison could thus be systematised. We analyzed the individual aspects and compared both sets (i.e., 1A with 2A, 1B with

2B, and 1C with 2C). Comparing the properties of the research sets enabled answering the research question.

Within this research, the comparative secondary analysis was used to develop an understanding of the insights that both methodologies generate within their narrow research questions. The aim of Paper 2 was to read and make visible the traces of everyday practices and to interpret urban transformation from the perspective of migration. By focusing on societal relationships within a migration context, this research sheds light on marginalised knowledge sources and shifts them to the core of the analysis.

3.3 Co-Modelling and Real World Experiments

Despite an increasing amount of literature calling for a participatory approach to the Digital City, participatory digital urbanism is still oftentimes limited to the design analysis phase pre-development, or a co-creative delivery of services and products post-development and frequently faces the challenge of difficult integration into procedures of local governments (F. Harvey et al., 2022). The third research paper addressed this gap by placing co-creation at the centre of digital urban transformation. It did so by adopting the perspective of Solman et al. (2022), which emphasises the inclusion of diverse stakeholders in the early stages of the development process of Digital Urban Twins. Paper III expands on the analysis framework from Paper I, delineating four essential conditions for a reflexive and transformative practice that is called co-creative twinning. The research in co-creative twinning, then, includes (1) examining the twinners involved, their needs and interests and the means of engaging a diverse set of stakeholders, (2) detecting emerging twinning practices and the reconfiguration of knowledge, (3) investigating agency and the sharing of decisional power, and (4) analyzing the process in regards to openness and reflexivity. By adopting this framework, the analysis provides a comprehensive understanding of co-creative twinning and its underlying elements. Following the above-mentioned conceptualisation of co-creative twinning, the research expands on existing participatory modelling frameworks established in resource management, and designs and applies a custom-made methodological framework to the twinning process. The experimentation phase took place from February through May 2023 and consisted of four consecutive workshops. The first happened online via a video conferencing tool, aided by an online whiteboard tool for note-taking. The other three workshops took place on-site in the City Science Lab, aided by a Digital Multi Touch Table. The goal formulation for the experiment phase was to design, implement, and test a co-creative modelling workshop methodology that would invite diverse stakeholders to the process. In the co-creative modelling process, a workshop methodology was designed, implemented, and tested, inviting diverse stakeholders to the process. In parallel, technological development took place, which was informed by decisions made in the modelling workshops. These two iterative processes intertwined and iteratively conjoined along the Timeline. Identifying relevant stakeholders involved in that realm and recruitment through a snowball system was an ongoing activity throughout the process. Between three to nine participants were present at each workshop, representing different areas of expertise relevant to the selected case study.

Two existing workshops methods were conjoined for this process: group modelling frameworks were used to collaboratively build a system dynamics model (Barreteau, 2003; Barreteau et al., 2014; Exter & Specht, 2003; Voinov & Bousquet 2010; Voinov et al., 2016); and an adapted ARDI methodology

was used to build an agent-based model (Etienne et al., 2011). Data was collected during the workshops phase and during the preparation phase, starting around late summer in 2022, in team meetings, both online and offline, during informal interviews with participants, expert interviews, in workshop settings and in reflection conversations. The material was gathered using participatory observation, informal interviewing, and document analysis, and consisted of observation notes, field diary notes, interview transcripts, meeting notes, photographs, audio recordings, emails, and other artifacts of communications such as PowerPoint presentations, as well as the workshop results documentation. The material was coded in MaxQDa using open codes (Oertzen, 2006). Of these codes, clusters of relevant aspects were formed in relation to the research question and the above-mentioned four dimensions of co-creative twinning.

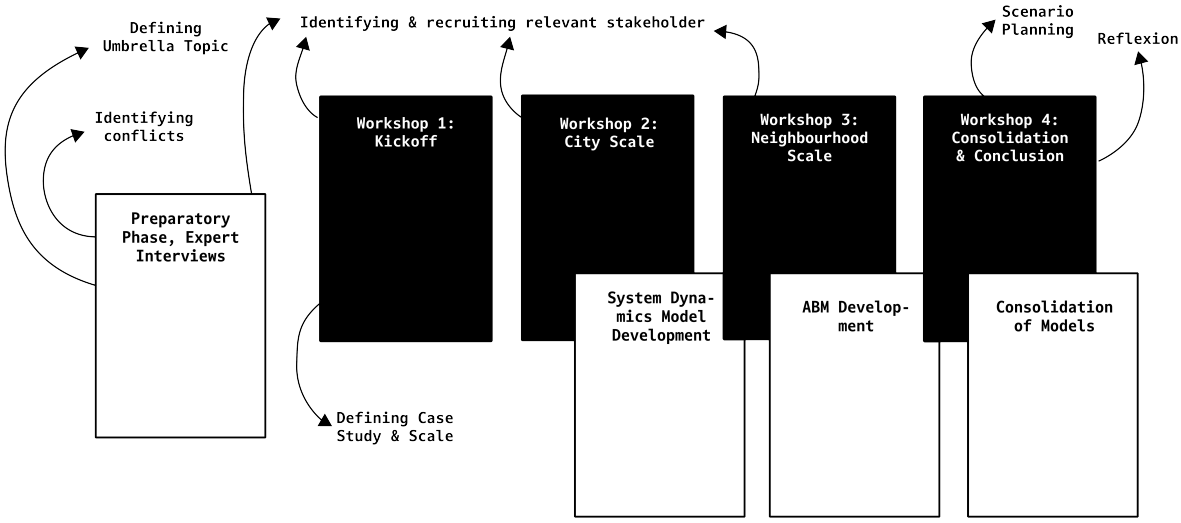

Figure 7: The co-modelling process in the CUT oscillated between planning and development phases conducted by researchers (white), and workshop phases with stakeholders (black).

3.4 The Co-creation Nucleus

This dissertation proposes a visual model of co-creation that will be helpful in understanding and analysing, as well as conceptualising and designing co-creative practices in digital cities: the Co-creation Nucleus (Figure 8). The Co-creation Nucleus takes recourse to the core elements of Co-creation: efforts related to the Stakeholders, Practices and Tools employed, and the extent of Agency deriving from the practice. The visual tool displays the building blocks within each core element of the individual practice and puts them in relation. Applied to specific co-creation procedures, it reveals which core element is in the focus of a practice, and whether the practice arrives at creating Agency and transformations external to the co-creation setting. In doing so, it serves as an analytical tool, however, it may likewise be used as a design tool when conceptualizing a co-creative effort.

Elaborating on this model, several logical implications follow. Stakeholder efforts are visualised with rhombs, Practices and Tools with arrows pointing inward and outward in regard to their deployment

as a function of the workshop, or as a medium creating outreach. The Agency is a dotted circle surrounding the co-creative practice. Arrows can permeate the dotted sphere when a practice enables a transformation beyond the setting. Although individual arrows permeate the sphere, any Agency emerging derives from the interaction of the individual elements.

The Co-creation Nucleus will be employed in the subsequent chapter as a tool for data visualisation and analysis.

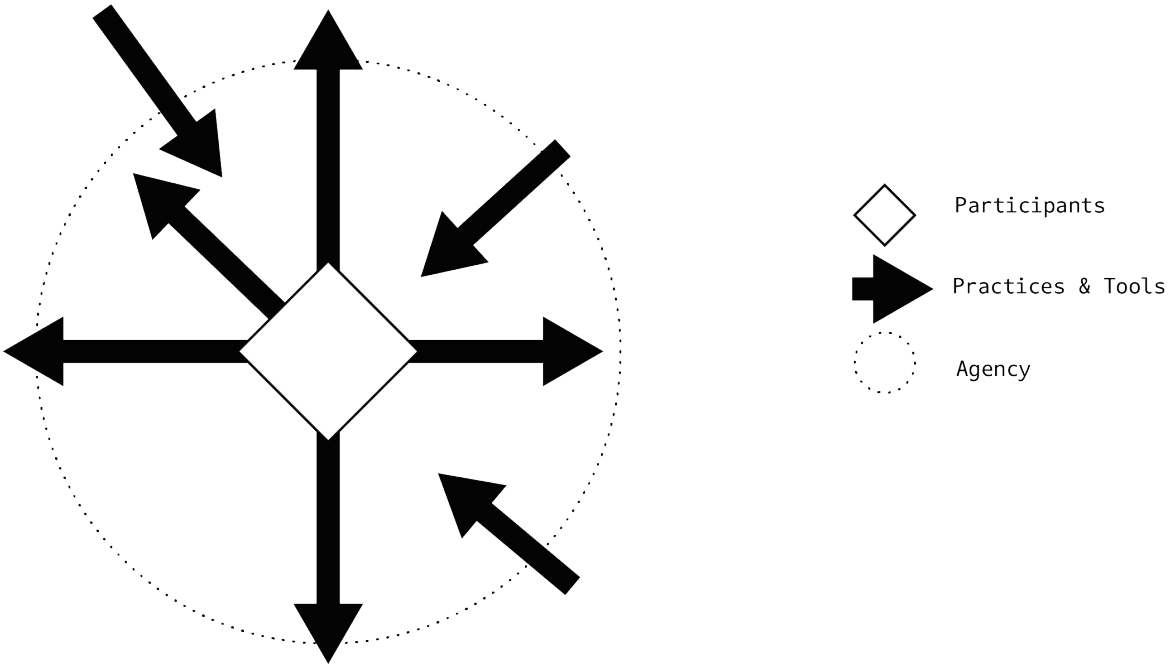

Figure 8: The Co-Creation Nucleus puts Stakeholders at the center, describes emerging Practices and Tools, and the extent of Agency. Efforts related to Stakeholders are at the center of the Nucleus, Practices and Tools are directed at internal collaboration and external outreach, and the sphere of Agency may be permeated by a co-creative practice.

3.5 Reflection-in-action

Within the three case studies, I have been employed as a researcher and facilitator, designing and implementing strategies of collaboration while examining their potentials. I took on several roles: I acted as a reflective scientist aiming to gain scientific knowledge both for the project and my own scientific interest on the co-creation of urban technologies; I acted as process facilitator as I initiated, organised, and structured experiments, co-creation workshops, participatory mapping experiments, discussions and evaluations; and I acted as knowledge broker translating scientific findings into concrete technical development needs. Embedded research necessitates a critical research practice that reflects on positionality and implicit assumptions. Donald A. Schön developed the figure of the *Reflective Practitioner* (Schön, 1983), claiming that reflexivity is constitutive of professional behaviour. Reflective practitioners are sensitive to their own entanglements in complex fields of action, and they practice *reflection-in-action,* surfacing and criticizing tacit understandings (Schön,

1983). In order to allow for reflection-in-action, my investigation oscillated between theory and practice. Phases of deep immersion in theory alternated with applied field research and allowed for critical distance and iterative modifications on either side. In writing a field diary, I recorded thoughts, feelings and reactions to situations; these proved to be helpful in the subsequent analysis as the subjective perceptions helped point out implicit patterns of interpretation. I am a trained Facilitator and Urban Designer, and my design practice is engaged with the transfer of knowledge. We impart knowledge by conveying texts, images, visualizations, actions – depending on your disciplinary background these are subsumed as texts (Barthes, 1978), or images (Rancière, 2009). Every image is a discourse that encodes a story (Rancière, 2009) – it communicates something and at the same time conceals something else. The challenge in knowledge transfer is to convey the object of research in its procedural and relational nature without reducing the complexity. I have attempted in doing so by rendering my research practice as well as the documentation of my findings and the suggested design principles open, reflexive and adaptable.

4 Data and Results

In the following, the main data is presented in relation to the Research Questions. Each subchapter presents data from the individual papers. Following the written presentation and utilising the Co-creation Nucleus, the data is then visually organised and analysed. This supports the deduction of key findings that are presented in chapter 5.

4.1 Values of Participation

4.1.1 Data

RQ 1.1 How can e-participation lower thresholds for participation and broaden outreach in absolute number as well as inclusiveness of otherwise difficult-to-reach communities?

In the DIPAS piloting events, participation was open to all, indicating a theoretically high inclusivity of participants. While online participation is likely to allow a higher inclusivity of participants, self-selection and knowledge about participatory procedures remain limited to a knowing group that are not representative of the larger public. As the piloting event took place in a neighbourhood predominantly inhabited by migrant families, the organisers hoped for a participation of these communities. However, the data showed that the majority of participants belonged to groups that have traditionally been integrated in planning procedures: namely people associated with the planning sector. The diversity of participants in terms of language and cultural background was not increased. Reasons for this might include a self-selection bias and a lack of awareness about the events. This points to two important interconnected aspects: (1) communication remains key for a successful participation; (2) dissemination of information has to be adjusted to the communication channels of those groups that are targeted. In order to target specific groups, “higher diversity” does not suffice to outline the desired group. If participatory agents want to include diverse groups of people, it should be outlined which groups are being targeted in order to plan and manage successful publicity and promotion strategies. Such delineations might be, but are not limited to: gender, age, knowledge background, class, involvement in certain urban planning domains etc.

Eligibility in this case study was less connected to the question of being allowed into a space, but rather on how high thresholds were for participation, in this case meaning interaction with the digital tool. Digital tools allow for less outspoken participants to engage. However, division between those who felt comfortable engaging with the tool and those who did not was pronounced. In comparison to offline, analogue participation events that oftentimes privilege verbally strong and self-confident people, the online participation tool allowed for the inclusion of people with different communication patterns. The digital touch surface of the tool allowed participants to directly interact with the tool and add comments without having to speak up. However, new thresholds were created along another division line: between participants who felt comfortable to interact with technology and those who were not. These findings reflect on the importance of facilitation during participatory events, especially those engaging with digital tools. Inviting participants to interact with the tool was of utmost importance and proved successful in encouraging hesitant participants.

RQ 1.2 Are preferences of citizens explored, developed and possibly transformed during a collective deliberation procedure?

A high level of collaboration has been observed in the interaction with DIPAS. Users retrieved available GIS data through the tool and underpinned and qualified their discussions. The interaction with and utilization of urban data in the physical workshop setting was found to facilitate a higher quality in discussions and an increased level of collaboration. The digital participation tool also allowed for a higher transparency as it showed the raw data. By retrieving the comments of others, users were able to develop shared ideas for the space. This shows the added value of using DIPAS, combining the best of both worlds, a qualified discussion of several participants who share a space, and the underpinning of geospatial data through the tool, qualifying discussions. DIPAS was found to enable collaboration facilitated by technology, allowing participants to exchange opinions, explore preferences and possibly transform ideas through the solicitation of data. Via the contribution form, new group preferences were communicated to officials, thereby allowing social choices to be transmitted to officials from any location, thus increasing scope and lowering thresholds for participation. However, it was found that the tool stays behind its potentials in increasing power in decision making, as the submissions by participants were transmitted as non-obligatory ideas.

RQ1.3 How are citizen commentaries transmitted to planners or results integrated into formal planning systems?

In the first development phase of DIPAS, no direct transmission function existed. Citizen comments were exported in an Excel table and transmitted to planners in this form. The planners, then, forwarded these files to external service providers analyzing and interpreting the results, answering with a presentation of key results of the whole participation process. This double translation diminished the potential for transparency and accountability that an online procedure might develop. Planners expressed their discontent with the missing feature, having expected the tool to automatically analyse the data and present citizen's preferences in an easy to digest way. This sheds light on the disadvantages of digital participation in that it creates big amounts of data that need analysis, meeting restricted resources of public authorities who need less amount of data on their hands, not more. Further endeavours need to evaluate whether a sheer increase of quantity is desired or if a qualitative feedback might have better chances of influencing official plannings as they will be easier to read, digest, and incorporate in plans.

The paper also found that the integration of these data into the planning processes remains a question to be addressed. The research addressed informal participation procedures. These are always additional efforts and their results have no legal binding power. Thus, citizen contributions remain recommendations that do not develop authoritative power. Instead, their impact depends heavily on the planners involved with the data and whether or not they deem the citizen contributions valuable for their plans. An additional threshold is the transmission of results to planners outlined in [RQ 1.4]. Media breaks between the workspace and computer programs used by planner and the data format of the transmitted results are likely to negatively affect the uptake of these results. Further development should question the possibility of an integration of planning results into the technological systems planners use in their workspace. If citizen commentaries can be accessed via the planning and mapping tools officials use, they might be more likely to be taken into consideration.

4.1.2 Visual Analysis

I have started the visual analysis by delineating the building blocks of each of the core elements of the co-creative practice deployed in Paper I. These might be specific efforts taken in regards to the Stakeholders, Practices & Tools, and Agency, such as ‘Open Invitation’, ‘Development of shared Ideas’, and ‘Manual transmission of data’. Subsequently, these elements were mapped in the Co-creation model. Building blocks regarding the Stakeholders are positioned in the middle, as they represent the core of a co-creative practice. Practices and Tools are visualized as a relation between Stakeholders and Agency, with some arrows permeating the sphere. This permeation represents outcomes that disseminate outside of the co-creation setting, thereby representing transformations that reconfigure decision-making power and agency beyond the individual practice.

Visualising the DIPAS procedure on the Co-creation Nucleus helps understand the focus on practices and tools within this case study. This focus is plausible as the DIPAS case study was employed in order to test the tools and refine them with regards to user feedback. The open source participatory platform lends some Agency to the feedback of users gathered in the study, as their input guided the further development. Although the displayed input of citizen comments disseminated knowledge outside the participatory event and lending permanence to the comments, the effects on Agency within this case study remained limited.

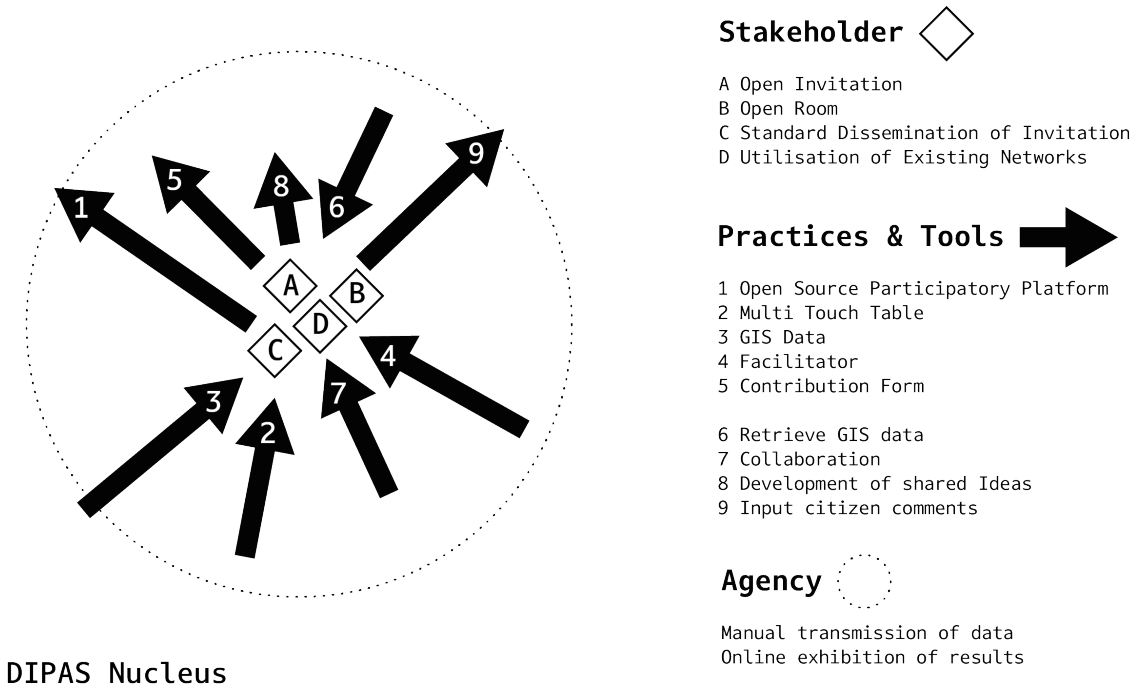

Figure 9: A visual analysis of Paper I utilising the Co-creation Nucleus.

4.2 Co-creation with marginalised communities

4.2.1 Data

RQ 2.1 How can marginalised communities be invited to co-creative efforts in digital cities?

The success of co-design and co-creation processes involving marginalised and vulnerable groups highly depends on a number of predetermined settings. One main aspect is how the physical space and environment of the workshops are created in terms of size, location, and atmosphere (Sanders, 2013). Sanders & Stappers (2008) suggest eight guiding principles for conducting meaningful workshops in order to build a healthy environment for co-creation (Sanders & Stappers, 2008, 7–8). In addition to the factor of (1) the right environment, they highlight the importance of (2) a well-trained and skilled facilitator, (3) a clear definition of the needs of the target group, the aims and the tasks, (4) involving all relevant stakeholders, (5) developing a common value and vision during the process, (6) involving stakeholders at the right stage of the process, (7) being able to handle upcoming conflicts and varied interests and (8) reflecting and considering feedback on the whole co-creation process afterwards. In the MICADO project, two of the user groups were invited to the co-creation: migrants and representatives of civil society organisations. Specific measures were employed to raise awareness of power imbalances between researchers and research participants and counterbalance it. Researchers involved in conducting co-creative workshops participated in anti-discrimination training and the MICADO workshops were designed to mitigate the effects of differing levels of privilege and power. Four of the workshops were targeted at specific groups according to categories that had previously been identified: refugees and asylum seekers, female migrants, migrants who had lived longer than five years in the arrival country, and a mixed group of migrants from various destinations. This separation allowed facilitation of a group discussion, provided a safe space for all participants, and distributed participation between groups according to what were assumed to be different migration experiences. The invitation to the workshops was extended through civil-society organisations that were already involved in the research project and which distributed the call across their wider networks. The workshops were held in the afternoons and evenings to allow people with work and care responsibilities to participate, and they were conducted on the premises of civil-society organisations in order to create a more trustful environment for the migrant participants.

RQ 2.2 How does co-creation lead to a reconfiguration of knowledge?

In comparing the two datasets of the systematic literature review and the co-creation workshops, the research delivered three crucial findings on the effects of employing co-creation in the development of urban technologies:

Co-creation reveals thematic fields that are overseen in quantitative analysis: The comparison of the two datasets showed that both research methodologies delivered very different results. While the body of literature found more results on the topics of education, labour, and participation and fewer on the fields of housing and health, the co-creation found data more equally spread between the domains. This indicated a higher relevance of topics that were overlooked in the body of literature. Furthermore, the co-creation workshops raised questions regarding challenges in the domains, and

participants described their issues and experiences on individual levels. While an SLR can be helpful to detect a certain dominance as well as gaps in a specific research field, only a co-creative practice with the target group helped gain information on distinct and individual experiences.

Co-creation sheds light on policy effects on a local and individual level: While the majority of papers in the SLR displayed results at a national or international level, most data derived from the co-creation workshops had a local or regional scope. The explanation is the proximity of a migrant's experience to local infrastructures. This divergence enlightened gaps between policy and their implementation which can be illustrated by two examples from the research. While studies in the SLR focused on the positive effects of anti-discriminantion provisions to decrease wage discrimination against migrants, migrants in the co-creation workshops expressed their experiences of discriminatory behaviour during job interviews, related to the wearing of religious symbols. Another example showed that while the SLR discussed the relationship between residential segregation and neighbourhood satisfaction, migrants in the workshops expressed their experience of alienation in their housing context. While the SLR assessed knowledge of formalised systems, shedding light on major migration policies, systemic border regimes and identity politics within these five thematic fields, the co-analysis workshops with migrants and representatives of NGOs surveyed everyday practices and tacit knowledge connected to overcoming challenges in the same five domains. A closer look at these differences reinforces the argument that while quantitative methods provide knowledge on formal frameworks and policy levels, qualitative data from co-creation sheds light on individual, often informal patterns that facilitate or hinder a policy to become fully effective. The examples of wage discrimination and residential segregation discussed above show that while an SLR gives an overview of formalised systems and policies, only co-analytic research with migrants offers explanations as to how or why policies at times do not have a positive influence on integration procedures.

Co-creation makes latent and implicit knowledge tangible by bringing to light individual strategies and responses triggered by national policies: The SLR showed a general focus in the articles, presenting summarised results to offer insights into nation-wide policies. In the co-analysis workshops, individuals shared their challenges, focusing rather on individual issues and strategies. The data showed descriptions of the multitude of information points a migrant would frequent during their arrival process, in order to receive necessary information about opaque, formalised processes. These conversations illuminated the individual, sometimes informal and nuanced narratives that are highly relevant if one seeks to understand the complex structures of integration processes, and the facilitators and hindrances of success. These differences in the results show that while quantitative analysis enable insights at a national and international level and focus on policy impacts, research that lets actors and city-dwellers participate makes visible individual daily practices and tacit knowledge, thus shedding light on multi-perspective, transdisciplinary, and human-centric research areas. Expanding the narrow researcher's perspective by involving vulnerable groups in participatory research such as co-creation brings their tacit knowledge repositories into focus.

4.2.2 Visual Analysis

Visualising the second case study within the Co-creation Nucleus, several findings can be derived. Regarding the design of the workshop, the model illuminates the focus on stakeholders' needs. Attention to the workshop space and timings illustrate this. Regarding practices and tools, the sparse

but well defined workshop methodologies supported the co-creation without taking attention away from the participants. As a result, the storytelling unveiled valuable knowledge. Agency emerged as a result of the scientific evaluation and transmission of results to developers as needs & requirements for the technology. However, the arrows do not protrude widely beyond the sphere of the individual setting, illuminating that Agency did not expand further outside the research project.

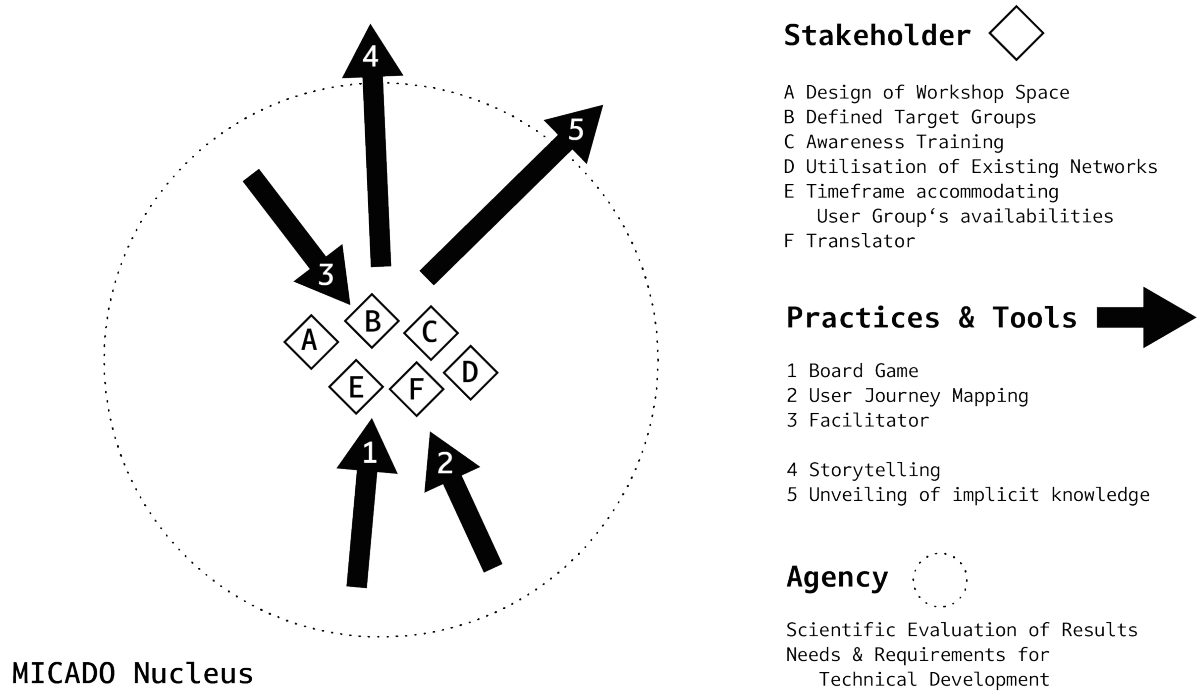

Figure 10: A visual analysis of Paper II utilising the Co-creation Nucleus.

4.3 Developing Agency

4.3.1 Data

RQ 3.1 What are the conditions for and the access to participation in a co-modelling approach?

Digital Participation procedures and co-creative efforts in the Digital City oftentimes lack engagement of diverse stakeholder groups. An explanation for this is their frequent lack of proximity to the daily challenges of city actors. A challenge is to motivate these actors into participating, even if the outcome or benefit of their participation is not yet clear to them. In the CUT project, existing relationships and personal networks played a crucial role in recruiting participants. Trust in the existing relationships motivated some participants to join the efforts despite a lack of understanding of the project. During the co-modelling process, these existing bonds played a role as participants coordinated their inputs and formed alliances to push their shared agenda. Participants were invited based on their expertise in the field, and their knowledge of the context and existing networks within the context let them include perspectives from non-present roles, helping further enlightening the

subject. Limited time resources were a hindrance for the participation to many, and coordinating the time with differing schedules was a challenge. The motivation to clear the schedule for the project was influenced by how well the scope of the experiment was understood. The perceived potential for impact was another crucial factor hindering or motivating participation.

RQ 3.2 Which practices of acting with and through digital tools emerge when citizens actively engage in modelling activities, and do transformative moments emerge by the active contribution of participants to the design and implementation of the twin?

Models are powerful tools that shape thinking about complex matters as they simplify the representation of reality. In order for a co-modelling activity to be transformative, the phases of framing and conceptualization should play a fundamental role. By rendering these phases as parts of our co-modelling workshops, the challenge of abstractness emerged, stemming from the models themselves but also from the iterative development process. Our stakeholders expressed difficulties imagining the outcome or creating a mental picture of the solution and its benefits for them, or even understanding what was being built. New practices of engaging within digital city co-creation was making things explicit. Participants asked each other, explained concepts, clarified abstract notions, specified ideas, and dealt with complexity. These practices emerged during the co-creation, when participants discussed or worked with the tool to input their ideas. Spontaneous exchanges happened in which the above-outlined practices emerged, and which were facilitated by the researchers who also contributed their knowledge to the group. Through this, new sets of knowledge emerged in participants, and this was aided by the digital model that facilitated and made explicit factors.

An important part of digital city models is georeferenced urban data, and working with data requires new ways of thinking with and through data. Applying data sets to the modelling process seemed easy to the participants. What emerged as a challenge was the work with unquantifiable, or 'softGIS' data (Kahila & Kyttä, 2009; Kyttä et al., 2023). Quantifiable and standardised data are the backbone of many, if not most smart city applications. However, these datasets are not available for every topic, specifically when it comes to social phenomena: in this case, gentrification processes and neighbourhood push-out dynamics. By building the model, participants were supposed to name datasets that would be helpful in explaining the topic. However, some of the phenomena important to social processes are difficult or impossible to quantify. The task was to nevertheless imagine datasets that could be helpful. To give an example, one aspect deemed important for our case study was the social cohesion of a neighbourhood. In quantifying this phenomenon, participants discussed whether the number of social contacts might describe social cohesion, or rather the quality of these contacts, or something else entirely. These discussions proved important again for making explicit data and knowledge gaps in digital cities.

Including a variety of participants proved to be helpful in filling knowledge gaps. Participants provided their knowledge in their and in related fields, taking on different expert roles. When gaps in the model emerged, several participants noticed them and closed them with their knowledge.

In multi-stakeholder collaboration, it is natural that different perspectives come together. Different strategies are employed when confronted with a differing perspective, like objecting, overruling, finding consensus, and agreeing. We found that when opposing perspectives collided, negotiation and

constructive discussions took place. By having the same objective and working on a goal, participants were more inclined to overcome their differences and find constructive solutions.

We also found that participants appropriated the process. Due to the relevance of the case study, they showed great interest into gaining knowledge and connect to others in the field. The co-creation process thus had an added value for their work and contributed to their professional networks. This went so far that participants developed a sense of ownership. They captured the work steps for their own professional purposes, showed great motivation to shape the outcome, and took pride in the final product. Some expressed the wish to present the product in their own professional contexts, carrying the tool away from the laboratory settings into the realms of their work.

RQ 3.3 How is the process of co-creation open to emergence and uncertainties?

Building a digital model is an abstract undertaking, and turnout for participation is often influenced by this fact. In the case of CUT, participants expressed that at times, they were confused, but that confusion ultimately turned into understanding. They held a tolerance for disorientation thanks to a secure framework in which participants always knew what the next step would be, guiding them through the discomfort of not understanding. This was the part of the design of the process that allowed for order and disorder to emerge. A systematic agenda and strict timing provided a framework that allowed for productive collaboration even in moments of confusion. Openness was an important factor in this process, as some process steps were defined only in the step before, meaning that we could not outline each process step prior to commencing. This allowed participants to alter the process and thus the results, producing a diversity of representation of reality.

4.3.2 Visual Analysis

Visualising the third case study with the Co-creation Nucleus, several findings guide the analysis. It becomes apparent that an increased effort was made regarding the stakeholders, and the design of the workshop space, timing, and methodology catered to their needs. However, an outstanding emphasis lies in the selection of tools and practices. The selection of tools and data supported the co-modelling activities and enabled multiple valuable practices, such as an extensive deliberation, a coordination of inputs, and constructive problem solving. The input and quantifying of softGIS and the modelling activities within the open source modelling environment supported a dissemination of knowledge beyond the realm of the workshop setting as well as beyond the project. Agency emerged as a result of an open process that let stakeholders formulate an impactful challenge, motivating further participation and enabling the emergence of ownership. The opportunity for participants to strengthen existing and new bonds with experts in their field, as well as the possibility of appropriating the tool and taking it into other contexts further illustrates the dissemination of knowledge and agency beyond the co-creative setting.

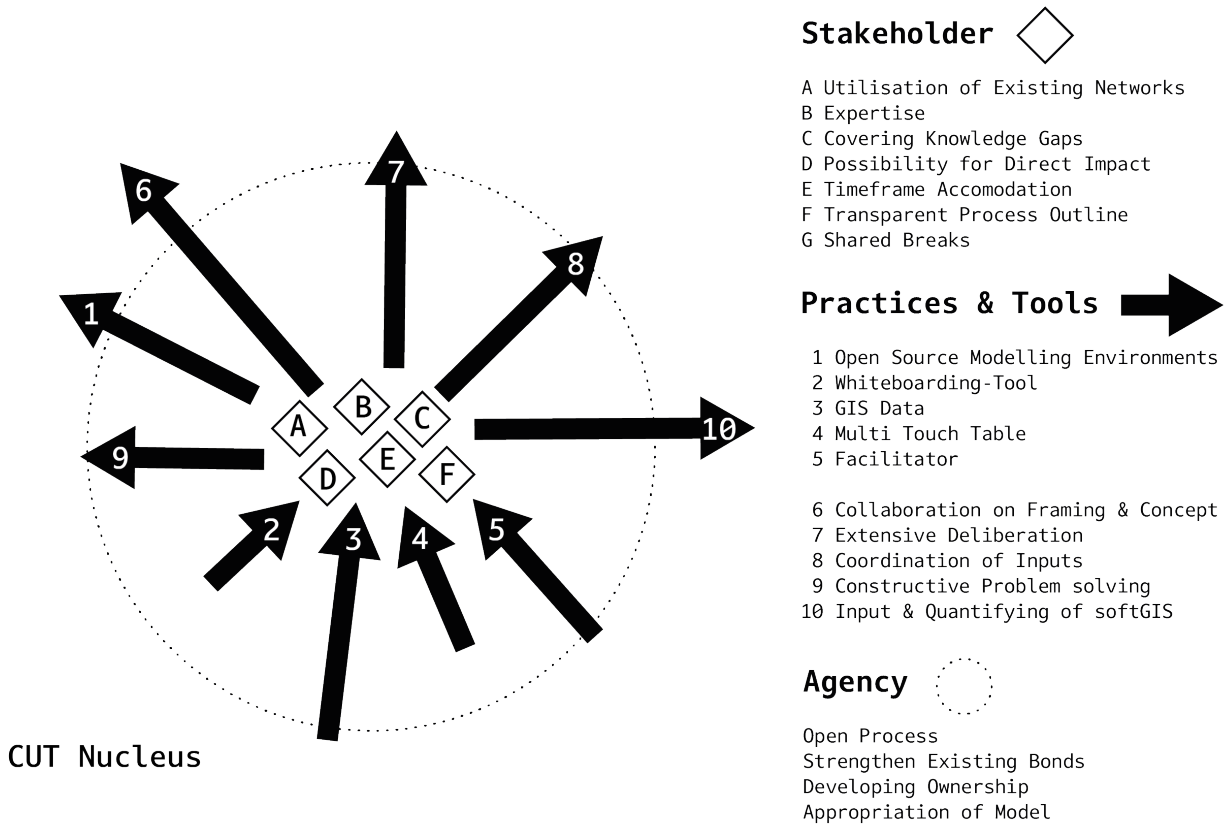

Figure 11: A visual analysis of Paper III utilising the Co-creation Nucleus.

5 Discussion and outlook

5.1 Key Findings and Linking to Previous Research

I look at participation not just as a starting point for, or an outcome of, the development of urban technologies and data driven tools, but as the very means to build these. Examining the construction of urban technologies and data-driven tools and their connection to participatory digital urbanism is a key task in understanding the wider implications of participatory processes within socio-technical systems. In contrast to attempts examining co-creation and participatory urbanism as disentangled from their underlying technologies, valuable insights can be derived from examining co-creation with, during the construction of and as an effect of digital urban technologies and data-driven tools. This dissertation asks the two-part question: **How can participatory and co-creative principles be employed in the development of urban technologies and data-driven tools, and how does their implementation transform perspectives, knowledge, and agency within the Digital City?** By taking on an interdisciplinary approach and examining concrete case studies involving social scientists and computer scientists in applied research and experimentation settings, this research describes applied design principles of co-creative methodologies, and specific approaches for software and hardware solutions. In realising the three overarching Research Objectives (RO1) Reconfiguration of Stakeholders, (RO2) Novel ways of Thinking and Acting, and (RO3) Facilitation of Agency, this chapter offers a combined analysis of the individual three papers' research results. By addressing the transformational effects of a co-creative practice in the development of digital urban technologies and data driven tools, this research helps enlighten structures of inclusion and exclusion, of power and limitations of their functionality, and offers a valuable addition to design principles for the Co-creative Digital City. By addressing existing gaps and developing approaches for a transformational collaboration in digital cities, this thesis brings the co-creation of urban technologies one step forward and helps to transform scientific, democratic, and political orders in the digital city.

5.1.1 Reconfiguration of Stakeholders (RO1)

In this thesis, the paradigm of participation was questioned. Research often puts a focus on a paradigmatic view on participation in the digital city – the more, the better. This approach fails to differentiate on who is participating, on the regimes of inclusion and exclusion, and on the value of contributions to the urban issue at stake. Rather than facilitating high levels of participation in the digital city, this research interrogated concrete values in terms of inclusivity, creativity, and agency in participatory efforts. This thesis assesses **how a co-creative practice within the digital city invites and includes a higher diversity of stakeholders, and if that concludes in a higher quality of results**. In answering this research objective, several findings from the three papers shall be pointed out.

As investigated in Paper I, the selection of participants is frequently the "make-or-break" of successful participation. In this case, invitations were extended through the communication channels of the responsible planning authority, using email newsletters, posters, and other forms. This open invitation to the piloting events did not lead to a higher diversity in the selection of participants.

Rather, it seemed to pose even a higher threshold for marginalised groups due to self-selection and information bias. The results concluding from the piloting events proved to be of mixed quality. As their transmission was not facilitated by the tool, planners expressed overwhelm with the amount of data and the format of data presentation. This points to the importance of easy-to-use interfaces and backends for expert stakeholders, and a strategy for handling big data.

In the second research paper, co-design activities for the MICADO application were designed for and tested with three distinct user groups, engaging members of civil-society organizations and migrants from different geographic, cultural, and educational backgrounds. The invitation for participation was extended through civil society organisations and their extended networks, which resulted in a higher communicative effort, but helped successfully address the targeted groups. However, due to these timing issues, we found it to be difficult to include these external stakeholders throughout the project runtime. Those who participated in their professional roles were easier to reach long-term, but communication with the vulnerable groups proved to be difficult due to timing issues and changing life circumstances. Despite having expressed difficulties in allocating time due to jobs and care work responsibilities, stakeholders expressed a high motivation to participate, as the topic of arrival processes posed an extremely difficult, work-intense, and likewise crucial issue for creating a healthy, prosperous and happy livelihood. Through the precise targeting of stakeholder groups, and the careful design of the workshop setting and methodologies, the co-creation workshops delivered specific answers about tacit knowledge and informal practices of marginalised groups. This reinforced the argument that while quantitative methods may be helpful in providing knowledge on formal frameworks and policy levels, qualitative data from co-creation sheds light on individual, often informal, patterns that facilitate or hinder a policy to become fully effective. This knowledge had previously not been generated through research in the existing literature and proved to be valuable insights for the development of the service app. These insights were then aggregated and translated into development needs.

In the third paper, co-creation was employed for the collaboration of stakeholders and computer scientists tasked with the development of a complex socio-ecological process in a digital urban model within the CUT project. Invitations to participate were extended through the professional and personal networks of the scientists involved and the research institution's network. This involved reach-out via email but also multiple personal conversations and proved to be quite intense in terms of time and work. The relevance of the case study topic proved to be a motivator to participate, however stakeholders also expressed difficulties in allocating time for the multiple workshops due to scheduling conflicts with labour and care work. Some stakeholders that we approached expressed doubts into the impact of the project and denied participation. The co-modelling activities resulted in a specific digital model showcasing aspects of the topic that were included by participants and reflecting their needs and interests. The turnout proved to be higher and the intensity and concreteness of discussion to be increased through the facilitation of the model. However, the quality of results in a participation setting also depends on personal relationships and trust, and the relevance of the issue discussed to the participants. Including a broad variety of participants broadly from the same field proved to be helpful in filling knowledge gaps, as participants took on different expert roles. During the co-modelling process, existing bonds played a role as participants coordinated their inputs and formed alliances to push their shared agenda. Participants were invited based on their expertise in the field, and their knowledge of the context and existing networks within the context let them include perspectives from non-present roles, helping further illuminate the subject.

In analyzing all three papers regarding the first research objective, several key findings can be derived:

1. Open invitation does not necessarily result in a diversity of participants. Higher inclusivity can be reached through specific targeting. Co-creative city makers should carefully reflect which perspectives shall be included in a co-creative effort. This entails asking whose perspectives have been overlooked and marginalised, and whose knowledge might be helpful for the project. When aiming at a higher diversity, one should define the axes along which diversity shall be reached (i.e. age, gender, class, ethnicity, and so on).
2. Motivation to participate can be generated by a topic that has high relevance for the target group and a perceived proximity to the lived reality or professional occupation, or by the perceived potential of creating impact. The motivation to clear the schedule for the project was influenced by how well the scope of the experiment was understood. This is directly linked to the communicative efforts. Compensation might be a valuable motivator, especially for underprivileged target groups.
3. Personalised recruitment through professional and personal networks might necessitate a higher communicative effort but can likewise result in a higher motivation to participate even in longer procedures involving multiple workshops.
4. All aspects of co-creative efforts shall be designed with the specific target group in mind. This includes, but is not limited to, room, time, methods, language, and tools. Allocating time sensitively with regards to labour and care work responsibilities of target groups leads to suitable timings. Choosing and designing safe and nearby spaces for vulnerable groups increases their likeliness to participate and fosters the quality of discussion.
5. Co-creation with specific target groups unveils tacit and implicit knowledge. This is highly dependent on the selection of stakeholders and the methodological design of the workshop.
6. A high quality of results does not necessarily result in better tools and technologies or more agency experienced. Careful consideration should be done regarding the translation of workshop results into technical requirements and communication to project externals. It is also of importance to make results available to stakeholders so that they can use them and move them into their respective contexts.

5.1.2 Novel Ways of Thinking and Acting with and through digital tools (RO2)

Including diverse perspectives in a participatory effort has been shown to be a crucial element of successful co-creative efforts. However, understanding how knowledge is reconfigured by bringing together these diverse perspectives is equally important. Shifting focus from deliberative practices towards those of collaborative action, this thesis uncovers new ways of Thinking and Acting with and through digital technologies and data driven tools. The thesis describes **how a co-creative practice enables novel ways of thinking and acting with and through digital technologies and data driven tools**. Insights from the first and third papers shall answer this research objective. The second paper engaged with stakeholders prior to development, thus has no findings on the interaction with digital technologies and data driven tools.

The first paper found that the interaction with GIS data in a participatory platform facilitated a higher quality in discussions. Users retrieving data through the tool whilst being situated in the physical workshop setting underpinned and qualified their discussions. In doing so, they were able to develop shared ideas for the urban space. The participatory platform was found to enable collaboration, allowing participants to exchange opinions, explore preferences and possibly transform ideas through

the solicitation of data. It was found that participants, being invited to discuss with others face to face, were engaging in a discourse and collaboratively developing planning ideas which they would then suggest. The heightened quality and depth of these contributions compared to simple and singular online commentary points to the importance of working with digital tools in moderated onsite settings. However, we found that the interaction with the platform required facilitation. Attention to the design of user interfaces and the user experience shall be paid in order to build tools that invite sovereign engagement.

A common challenge in recruiting participants for urban co-creation is the perceived level of abstractness of urban planning projects for people unfamiliar with the terms and regulations. The co-creative modelling practice described in Paper III showed that the workshop setup enabled stakeholders in making abstract concepts explicit. Participants asked each other, explained concepts, clarified abstract notions, specified ideas, and actively dealt with complexity. Their knowledge not only on urban planning issues but also on software development was reconfigured, as they pointed out in reflection interviews. Constructive exchange was facilitated by researchers and by the digital model. By having the same objective and working on a goal, participants were more inclined to overcome their differences and find productive solutions.

Geoinformation system (GIS) data are the backbone of participatory platforms such as DIPAS and CUT, and traditional GIS data is qualitative by nature. In our work, we collected individualised data and knowledge that is otherwise invisible in geographic information. This qualitative information on social spatial patterns, or 'softGIS' (Kahila & Kyttä, 2009), can potentially help find empirical evidence of topics that are important to stakeholders. Integrating softGIS into GIS platforms can be challenging, as they are at times geographically imprecise and fuzzy. In our case, these topics were gentrification processes and neighborhood push-out dynamics. By building the model, participants were supposed to name data that would be helpful in explaining the topic, resulting in terms such as 'social cohesion of a neighborhood'. As the analysis of qualitative GIS data is quite laborious, we wanted to find quantifiable qualitative data, or 'hard softGIS' (Kyttä et al., 2023). In asking the participants to find quantifiable datasets for the social spatial patterns, enlightening discussions proceeded. These proved important for making explicit data gaps – and thus, knowledge gaps – in the digital city. Ultimately they enabled participants to develop the skill of 'thinking with data'.

The inclusion of facilitators proved to be a crucial point in the interaction with technology and within the workshop groups. As this research has shown, participants were more likely to engage with the digital tools when a facilitator was present and encouraging an interaction with the tools – especially for stakeholders with a self-perception of low technology experience (paper I). This finding supports the argument that when deploying digital tools for public participation, these should be accompanied by either a human or digital facilitator in order to avoid exclusionary effects due to a digital divide. Further research could examine digital facilitators such as data storytelling tools and facilitating User Interfaces and Experience Designs.

In analyzing the papers regarding the second research objective, several key findings can be derived:

1. The interaction with GIS data, participatory platforms, and digital urban models facilitated a high quality in discussions. These technologies enable collaboration in allowing participants to exchange opinions, explore preferences and possibly transform ideas through the solicitation of data.

2. The right workshop methodologies and tools can facilitate a reconfiguration of knowledge. Our co-modelling practice showed that the workshop setup was helpful in allowing participants to explore, explain and clarify abstracts notions and unknown concepts. The methodology and tools also supported stakeholders in finding constructive solutions for conflicts.
3. Co-creation data, just like softGIS, helps close data and knowledge gaps. This data reveals thematic fields that are overseen in quantitative analysis, and collecting softGIS input on social patterns in digital city models helps support the arguments of stakeholders and showcase themes and topics that are important to them.
4. In trying to quantify qualitative data, participants accustomed themselves with the practice of 'thinking with data'. Including softGIS on important public topics in digital city models can help relate to these tools.
5. A digital divide was not perceived along the lines of age, rather on the line of tech-savviness and personal preference, which has a gendered perspective. Facilitators proved to be helpful in increasing engagement with the tools.

5.1.3 Facilitating Agency (RO3)

Data and digital tools has been found to facilitate a reconfiguration of knowledge and support collaboration. Moreover, transformational design aims at instigating change in the actors of the digital city. Focusing on the notions of agency and ownership helps understand this. In doing so, this thesis illuminates **how a co-creative practice enables sharing of decisional power and ownership between the stakeholders of the Digital City, and how this enables stakeholders to critically reflect on system pathways and improve the requirements for sustainable change.** Findings from the three papers shall be presented in order to shed light on these questions.

Criticism has pointed to the limits of participation and co-creation, when the practices instrumentalise citizens without sharing authority or power (Miessen, 2012; Mouffe, 2013; Rancière, 2008; Turnhout et al., 2020). In paper I, the emergence of ownership and agency was measured by examining the transmission of input from citizens into formal planning systems. In the first development phase of DIPAS, citizen comments were not transmitted directly, but exported into a digital file and sent to planners in form of a table, resulting in a media break. The planners, then, forwarded these files to external service providers analyzing and interpreting the results, answering with a presentation of key results of the whole participation process. This double translation aggregated individual voices which might increase the urgency of topics but diminished the potential for transparency and accountability that access to the raw data might have provided. The reason for this workflow was an overwhelm with the sheer amount of qualitative data derived from the public participation process. Planners expected an automatic analysis of the citizens' input. This sheds light on the disadvantages of big data in public participation, meeting restricted resources of public authorities. In the second project phase, content was directly transmitted to planners via an interface in the participatory platform. New group preferences were communicated and social choices were transmitted to officials from any location. This increased scope and lowered thresholds for participation. Paper I also found that the integration of soft participation data into formalised planning processes remains an open question to be addressed. In informal structures, the results of citizen input are highly dependent on the efforts made by planners involved with the project. In the case of DIPAS, the presented research has shown that however thorough the results of communicative participation procedures might be, a lack of legal obligation and media breaks in the transmission of results lowers the impact of these efforts. These

findings support the argument that the development of ownership and agency in participatory and co-creative practice rely heavily on the integration of these efforts into formalised legal and technological systems.

Co-creation data, just like softGIS, reveals thematic fields that are overseen in quantitative analysis: The comparison of the two datasets regarding topics of importance in paper II showed that both research methodologies delivered very different results. While the quantitative analysis was helpful in detecting certain dominances as well as research gaps, the co-creation data helped gain information on distinct and individual experiences. Likewise, while the quantitative analysis presented results on nation-wide policies, participants in the co-creation shared their individual challenges when interacting with these policies, showcasing hindrances, and explaining individual issues and strategies when dealing with these hindrances. The co-creation data showed descriptions of the multitude of information points a migrant would frequent during their arrival process, in order to receive necessary information about opaque, formalised processes. These conversations informed the individual, sometimes informal and nuanced, narratives that are highly relevant if one seeks to understand the complex structures of integration processes, and the facilitators and hindrances of success. These differences in the results show that while quantitative analysis enables insights at a national and international level and focus on policy impacts, research that lets actors and city-dwellers participate makes visible individual daily practices and tacit knowledge, thus shedding light on multi-perspective, transdisciplinary and human-centric research areas. Expanding the narrow researchers' perspective by involving vulnerable groups in participatory research such as co-creation brings their tacit knowledge repositories into focus. This enables stakeholders to take ownership of their stories and experiences. However, the development of agency remained limited, as participants acted as input-givers for the scientists. The transmission of their stories into requirements for technical development remained at a rather general level, with the *provision of information* and *improvement of contact to officials* being two main requirements derived from these workshops.

Both papers I and II showed that the development of agency remained at a low level, with participant acting as input-givers to the scientists and the tool, but not developing a sense of ownership. This stands in direct connection to the level of openness in the design of the participatory methodologies and tools. While methodologies and tools for Paper I and II were heavily structured in order to provide concrete knowledge on specific research questions, they left little room for appropriating the process or tool for a participant's own goals. Only in Paper III, the research methodology and technology were designed with openness and flexibility as design principles, in order to allow for change and adaptation to other contexts. Specifically, the procedure invited stakeholders to collect and express concrete values and needs that were then translated into modelling efforts. This way, stakeholders were able to emphasise topics of high relevance. Due to the resulting relevance of the case study, they showed great interest into gaining knowledge and connect to others in the field. The co-creation process thus had an added value for their work and contributed to their professional networks. This went so far that participants captured the work steps for their own professional purposes, showed great motivation to shape the outcome, and took pride in the final product. Some expressed the wish to present the product in their own professional contexts, carrying the tool away from the laboratory settings into the realms of their work. Thereby, participants proved to have developed a sense of ownership over the digital urban model and the urban issue at stake. This is a result that the previous researches had not produced. A key element of this was, next to the openness of the process and technologies, a technological intersection with further systems, with the urban

model being integrated into the co-modelling platform of the CUT. The high quality and intensity of exchange and collaboration was another source for the development of ownership.

Designing with openness and flexibility as principles comes with its downsides. In our case, it meant that some process steps could not be predefined, as they relied on decisions made in the preceding step. This allowed participants to alter the results and thus the process, allowing for a diversity of representations of their realities. Participants expressed their confusion at times, but also that confusion turned into understanding. They held a tolerance for disorientation that was supported by the provision of a secure methodological framework. Even if they did not understand exactly the reason for a working step, knowing what the next step would be and trusting that things will eventually clarify helped guide them through the process. Designing a process that allows for a productive and trustful collaboration even in times of confusion can be supported by providing a systematic agenda and strict timing.

1. A direct result of digital public participation processes is the collection of big amounts of data as well as fuzzy, soft data. The integration of softGIS and big data into formalised systems is a challenge having to be addressed.
2. The development of ownership and agency in participatory and co-creative practice relies heavily on the integration and consideration of the results in political, scientific and technological systems. Media breaks pose difficult thresholds that are fit to lower the impact of participation procedures, and a lack of legal obligation or political motivation to include and consider participatory and co-creative data, results in depoliticised participation.
3. Co-creation has the potential of allowing participants to take ownership of their lived experience. Through storytelling and the provision of soft data on their lives and important topics, digital co-creation can enable these stories to be brought to a public eye, thereby allowing for agency to emerge.
4. A co-creative practice that puts openness and flexibility as leading design principles has the potential to facilitate the emergence of ownership and agency. By giving the process the flexibility to be adapted due to the interests and needs of stakeholders, it holds the power to work on topics of high relevance to the stakeholders. Only if participants perceive the topic to be of high relevance, might they be motivated to appropriate the process, topic or tool and bring it to other contexts. That is the space where co-creation supports the transformation of existing systems and lets participants formulate transformative pathways.

5.2 Limitations and Further Research

In the participatory urbanism discourse, a separation of agents has been pointed out, with critical scholars pointing out limitations while applied researchers developing technologies with little emphasis on their limitations. By bridging social and computer sciences in applied case studies, this research provides valuable insights into the concrete difficulties and promises of a participatory digital urbanism. By applying a transformative research agenda and critically examining the creation of the digital city of Hamburg, the dissertation formulates new visions and suggests practical interventions that will enable digital city makers to engage in collaboration that has the potential to transform stakeholders, reconfigure knowledge, and redistribute agency in the digital city. By suggesting principles of co-creation and co-creative coding in urban IT projects, this research describes new forms of: acting with digital urban tools; supporting the accountability and critical reflection of

software and decisions that govern how technologies come into being; suggesting new ways of producing and implementing urban technologies that take into account urban complexity and diverse stakeholder perspectives; and fundamentally allowing all stakeholders to take action in their Digital City towards a sustainable transformation.

Certain limitations can be pointed out that provide valuable basis for further research. In general, the examination of digital facilitators such as data storytelling tools, user interfaces and user experience designs remains a topic to be addressed.

The usability study in Paper I was a first attempt to assess the three-dimensional qualities of participatory processes. The analysis was done retrospectively on a piece of research previously conducted that had primarily focused on the technological development of the tool. Thus, the input remained limited in its significance regarding the quality of content. Further research could apply the Participation Cube on concrete participatory procedures and evaluate whether the quality of argumentation and level of innovation is increased by integrated systems.

It is yet to be seen whether a technological integration of results from informal participation procedures into administrative technical systems could ease access to that information and increase the uptake of these datasets into urban planning. This matter could be observed in further research after the implementation of such a technical intersection. Further research can also evaluate whether a sheer increase in terms of quantity of participants is desirable, of if qualitative data of lesser amounts is deemed to develop a higher impact on urban planning as they might prove to be easier to manage and digest.

Certain limitations in Paper II can also be pointed out. The project MICADO aimed at including marginalised communities throughout the runtime of the project. However, given the long project duration of three-and-a-half years, the high amount of time needed to be allocated for each workshop, and the precarious and oftentimes insecure and fragile livelihoods of migrants and refugees, turnout for participation remained low. Research aiming at engaging marginalised and vulnerable groups should pay attention to these material and timely restrictions and seek to provide compensation to participants while taking into account possible shifts in motivation.

Due to the recency of the research on co-creative modelling of a digital urban twin, limitations in Paper III exist in terms of the outcomes on the implemented digital urban model in terms of content, as well as on the transformational effects both process and tool provide in the city. Further research could focus on the concrete outcomes of these processes on digital urban twins, both in terms of the structure and quality of the resulting models, as well as the quality of the source code. An analysis of the transformational potential of real-world experiments has been made by Ziehl et al. (2023) and could likewise be done for this co-modelling effort. The questions how socio-ecological topics are represented in large datasets and how complexity in social issues can be visualised and publicly debated, remain. A framework for analysis and the definition of design principles for co-creative twinning would be a valuable next step for the research in digital urban twins.

Lastly, by developing the Co-creation Nucleus, this framework paper attempted to develop a novel model for the analysis and design of co-creation activities. Returning to the core elements of co-creation developed in this dissertation, Stakeholders, Practices & Tools, and Agency, this tool proved

helpful in visualising complex co-creation activities and illustrate relations and outcomes. Further attention could be paid to potential rules that govern the arrangement of building blocks within the Nucleus. Additionally, the application of the Nucleus for the design of co-creative activities remains a field to be explored. I look forward to further test and develop this model, specifically defining a set of Co-creation Building Blocks that can support workshop designers in shaping and structuring their endeavours.

5.3 Conclusion and Outlook

The research in Digital Cities is an interesting endeavour, as the ongoing digitalization of everyday life presents rapid shifts in terms of built environment, social and political processes, as well as technological advancements. Since I started my research for this dissertation, big advancements have been made and fiery discussions have come and gone. Deliberations of the Metaverse have made way for the current debates on the potentials and effects of generative AI on the labour market, knowledge creation, the environment, and our society at large. And until this dissertation will be defended and published, another technology might have disrupted our lives. I have aimed at following my research objective in a way that it remains relevant to city-makers even in times of rapid technological shifts.

This research has examined the transformational potential of co-creation in the digital city. It has found that participatory systems based on GIS data can support qualitative discussions and increase participation. It has examined and explained the lack of diversity in participatory publics and explained the fundamentals of recruiting and motivating diverse and vulnerable stakeholder groups. It has described how co-creative efforts can make latent and implicit knowledge explicit and improve technological innovations by reconfiguring knowledge. It has described how complex digital urban models can be co-creatively modelled, and that these efforts prove to be helpful in sharing ownership and agency in the digital city. Thereby, this dissertation is a valuable addition to the discourse, qualifying discussions on participation and co-creation in the context of digital cities. By presenting findings from concrete and applied research and development projects, this thesis offers digital city makers valuable methods and tools for co-creative efforts.

Since starting this research, the research field has transformed. The DIPAS project has been concluded and the system has been published as open source software[10]. Several communes have adapted the tool and implemented in their software stack. The MICADO project has been completed and the open-source prototype-level IT product is available for uptake[11], however as of January 2024 it has not been introduced into formalised processes in the partner cities of Hamburg, Bologna, Madrid and Antwerp[12]. The Connected Urban Twins (CUT) project is still running, and a website to showcase the co-modelling efforts is likely to be published in the months succeeding this publication[13].

However far the development of these technologies might be, this thesis has focused on providing valuable knowledge on the collaborations of humans. It has outlined principles that help facilitate

[10] More Information can be found on https://dipas.org/

[11] The repository is available on Github: https://github.com/micado-eu/

[12] News and more information on the MICADO project on https://www.micadoproject.eu/news/

[13] The publication will likely be announced here https://www.connectedurbantwins.de/aktuelles/

collaboration and it has explained how technologies can support this collaboration. Hopefully, these research results will prove to remain valuable even if the technologies described in this dissertation have transformed, developed, or ceased to exist.

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Appendix: Publications

Paper 1

Thoneick, R. (2021). Integrating Online and Onsite Participation in Urban Planning: Assessment of a Digital Participation System. *International Journal of E-Planning Research*, *10*(1), 1–20. https://doi.org/10.4018/IJEPR.2021010101

Paper 2

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Paper 3

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Integrating Online and Onsite Participation in Urban Planning:
Assessment of a Digital Participation System

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ABSTRACT

The present contribution offers an assessment of the development and implementation of the digital participation system in Hamburg, Germany. The system utilises open and public planning data within a web-based interface and a physical decision-support tool. These technologies are integrated in urban planning processes, namely through citizen participation and citizen engagement. The research presented in this paper assesses the impact of the digital participation system by evaluating three key aspects shared with traditional citizen-participation methods: (1) the selection of participants, (2) the modes of communication used, and (3) the authority and power. The assessment is based on the analysis of data collected from interviews and a usability and user-experience study. For the analysis and comparison of DIPAS to other participation formats, this paper introduces a visual assessment tool, the participation cube. The digital participation system is found to have diversified the selection of participants and improved collaboration with the general public. However, it did not facilitate higher decisional power, due to the lack of legal adjustments. The author argues that new forms of participation should not only rely on digital tools, but should also engage with the institutional and procedural context in which participation occurs. Several strategies are suggested to support an inter-disciplinary approach at the intersection of technical tools and traditional planning practices. These hybrid strategies would allow the seamless integration of citizen contributions into the creation of urban development plans.

KEYWORDS

Citizen Engagement, Collaboration, Digitalization, E-Participation

1. INTRODUCTION

The integration of citizens within urban planning processes has been a hot topic in the planning theory discourse, starting with the birth of Jacobs' *democratic urban planning* (Jacobs 1961). Ever since then, several tools and methodologies to achieve proper citizen engagement have been tested, all of which serve the fundamental principle that cities are made for citizens and thus citizens should have a say in how they are planned. That discussion between top-down large-scale strategic planning developments and empowered citizen action, started by Jacobs at the end of the 1950s, is still ongoing. Citizen

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participation is currently an approach successfully integrated within the planning processes of many cities, and an extensive body of literature emphasises its benefits (López Baeza, J., Noennig, J. R., Weber, V., et al 2020; Hälker, N., Hovy, K., & Ziemer, G. 2018; Lazzarini 2016). More specifically, recent studies focus mainly on two strains: either communicative methods as a way to increase the quality of participation, or digital participation procedures facilitated by technological development. This paper sets out to expand on the link between both, and to analyse the key aspects of participation using an applied example: an integrated e-participation system deployed in the city of Hamburg, Germany. The Digital Participation System (DIPAS, www.hamburg.de/dipas/) is the resulting product of a long series of participation projects carried out in the Free and Hanseatic city of Hamburg. DIPAS was implemented as a cooperation project lead by the Hamburg Authority of Urban Development and Housing (BSW) in cooperation with the Agency for Geospatial Data and Surveying (LGV) and the CityScienceLab of HafenCity University (HCU). The research and development project had the objective of developing, testing and implementing a digital workshop tool that would be used in physical participation workshops while intersecting with an existing online participation platform. [1] In this cooperation, HCU takes the role of performing scientific accompanying research, among other tasks – from which the present paper results.

The research presented first localises the topic within the participation and collaborative planning discourse, and introduces the *case study* of the Digital Participation System in Hamburg. Following this contextualisation, data collected in interviews and usability studies is evaluated and analysed through procedures following Fung's (2006) approach, the *Democracy Cube*. This section elevates the evaluation of participation from a two-dimensional assessment as it has been laid out by the fundamental *ladder of participation* concept (Arnstein 1969), towards a three-dimensional evaluation focusing on the selection of participants, the modes of communication and decision making and the extent of authority and power. By introducing the *Participation Cube*, a tool for visual analysis is used to help evaluate participation procedures. After that, the implications for the embedding of a DIPAS within procedural planning systems are discussed.

2. LITERATURE REVIEW

2.1 Communicative and Digital Urban Participation Approaches

Citizen Participation as part of political decision making in urban planning is seen as an instrument to redistribute power by including citizens in the process of determining the future of their cities and reducing political apathy and post-democratic feelings. Healey (2003) summarized the driving forces for this transformation: a world under globalization sees rising interdependencies between the global and local and creates fragmented social realities, and the recognition of social injustices being produced by spatial development lead to re-assessments of strategic planning. Specific emphasis is put on discursive elements within policy planning, shifting away from strictly empirical, analytic approaches towards those including argumentation and deliberation, local expertise, and tacit knowledge (Fischer and Gottweis 2012). Nowadays, participatory planning practices are being tested in a variety of political and social frameworks, not only in a European and US-American context (Degbelo et al. 2016; Conroy and Evans-Cowley 2006) but also in emerging economies such as Kenya (Onyimbi et al. 2017), South Africa (Lues 2014), Vietnam (Nguyen et al. 2015), Malaysia (Abdullah et al. 2016), and China (Li and Jong 2017), to name just a few. These ways of communicative planning recognise and give more emphasis to a diversity of meanings, knowledge and interests within local communities (Silva 2010).

In the last 15 years, digital technologies and new methodologies have been implemented in participatory processes. The web as an evolving platform of communication and exchange has lead to a paradigm shift: users move from being consumers to producers of content (Geiger 2012). Adding to this, digital services are increasingly utilized on mobile devices (Abdullah O. Al-Zaghameem, Omar

M. Al-Qawabah and Wajedah H. Al-Gmool 2016). In planning, this is represented by an increase in the use of digital tools including, geographic information systems, virtual reality technologies, computer supported working environments, and interactive social media tools (e.g. Silva 2010; Höffken and Kloss 2011; Gil et al. 2019; Bertelsmann-Stiftung 2010).

Several researchers focus specially on participation that is grounded in geoinformation systems (GIS). To refer to this particular type of public participation, Pánek (2019) establishes the term *GeoParticipaton* or *public participation GIS* (Brown 2017). Kyttä and Kahila (2011), arguing for new participation methodologies, set out to categorize localized experiential knowledge that is collected via user-friendly digital applications under the umbrella term *softGIS* referring to resident's knowledge repositories. Additionally, knowledge and capacity building need to be taken into consideration because levels of knowledge on the usage of mobile platforms might create new thresholds and thus pose a potential bias of social segregation linked to access and usage of technology (Abdullah O. Al-Zaghameem, Omar M. Al-Qawabah and Wajedah H. Al-Gmool 2016). Forms of participation that engage with digital technology and mobile services – henceforth referred to as e-participation – provide valuable opportunities for higher transparency (Coleman 2009), democratic co-governance (Ostrom 1990), and have the potential of reducing the gap between politics and citizenship (Bertelsmann-Stiftung 2010). They have the capacity to expand outreach and enable the digital evaluation and analysis of contributions (Zentraler Immobilien Ausschuss 2013), to provide better planning and urban management services, be more efficient, work at lower costs, and to be more collaborative and participative, transparent and accountable (Silva 2010)[2].

The shift from conventional planning tools towards the deployment of digital services represents a new paradigm not only for participatory procedures, but also in the urban planning field as a whole. Silva (2010) describes this new planning paradigm as a combination of two aspects: the extensive use of information and communication technologies, and the interaction between multiple urban stakeholders (ibid.). He argues that the evolution from conventional to digital tools should not only be seen as a technological shift, but it should also be accompanied by fundamental changes in planning procedures (Silva 2010). Research on participation under the new planning paradigm would require broadening the subject beyond the use of technical tools. Rather than limiting participation research to the evaluation of the utilisation of technology, e-participation research needs to consider new methodologies for participation (Kyttä and Kahila 2011) and should entail an analysis of the respective context (Kubicek 2010) by introducing the legal planning framework and focusing on the participants of e-participation events. E-participation research should examine the ways citizens engage and communicate with policy makers, and the extent of influence the engagement unfolds in regards to prospective planning processes.

2.2 The Legal Basis of Formal Participation in Germany

An important marker in planning contexts is whether a participatory procedure is formal or informal: formal procedures refer to participation that is legally obligatory, while informal procedures summarize a wider range of participation that is not mandatory and where results are not automatically provided as input into planning procedures. While political frameworks are very different in each country, common regulatory trends for formal citizen participation have emerged and been consolidated over the past years in Western and Central European countries such as the Netherlands, Germany and Austria. Moreover, regulations still may differ highly within one country in regards to informal citizen participation because federal states and municipalities issue their own guidelines.

Political participation in Germany was legally formalized for planning procedures in 1971 when it was included in the newly created Urban Renewal Act (Behörde für Stadtentwicklung und Umwelt 2013). Since then, formal participation procedures have become well established and have been included in state laws. For the implementation and adjustment of master plans, the law obliges a two-step participation of the populous. In the first step, a public discussion of plans takes places early in the process. These events are usually advertised to the general public in the form of posters and

an official written announcement. At this stage, the plans are not yet fixed but the objectives of the development project are displayed in concepts and preliminary drafts. Citizens can inform themselves, express their needs and interests as well as provide critique (Behörde für Stadtentwicklung und Umwelt 2011). In the second step, a public exposition of the aligned blueprint is made available to the public for a 30-day period (§ 3 paragraph 2 BauGB). During this month, citizens can see the draft, inform themselves and input their remarks. All remarks are to be examined by the public authorities and balanced against private interests (Behörde für Stadtentwicklung und Umwelt 2013).

In parallel, more direct and conversational modes of participation have emerged, summarized under the term informal participation, as they go beyond the legal, formalized participation. These procedures and methods are numerous and diverse, and include real labs, charettes, deliberative polling, open space, citizen budgets and many more[3]. However, since informal procedures are not legally binding, they require additional effort and hence vary in their embeddedness in formal planning procedures and thus in their impact. Additionally, the outcomes of these informal participatory procedures are limited and come across as recommendations rather than as binding agreements for actual urban planning practice.

2.3 Evaluating the Features of Citizen Participation

Criticism has pointed to the limits of participation processes: their oftentimes restricted political impact has been addressed as a mode for producing approval through placebo participation procedures, instrumentalising citizens without sharing decisional power, and de-politicising the public by muting marginalized voices through consensus-building (Arnstein 1969; Miessen 2012; Mouffe and Wagner 2013; Rancière 2008). Elaborating on concrete values might be fruitful in this regard, such as: *Who is included in the participation procedure? What are the modes of communication during the process? What shall be the outcome of the participation procedure?* (Fung 2006, p. 66) Reflecting on these questions helps not only in the analysis and evaluation of participation procedures, but also in the design of better, custom-made participation solutions. After all, participation is not to be seen as a mechanism to substitute political representation or expertise, but instead complement them (ibid.).

3. METHODOLOGY

3.1 Research Question

This paper evaluates the impact of DIPAS based on the question: *What is the added value of the integration of online and onsite participation in regard to the embeddedness of participation within urban planning procedures and institutions?* By answering this question, the research presented includes an investigation of the usage of the DIPAS tool during the first two development phases of the project and an analysis of the feedback provided by (1) participants ("citizens") of a Usability and User Experience study and of participation workshops during the piloting phase of the system, as well as (2) staff of municipal planning authorities ("planners").

3.2 Introducing the Case Study: Communicative Planning in Hamburg

In 2012, the senate of the city of Hamburg established the "Urban Workshop" (Stadtwerkstatt), an administrative institution that coordinates all informal citizen participation procedures for topics of planning and environment in the city of Hamburg (Behörde für Stadtentwicklung und Umwelt 2013). This department is part of the Authority for Urban Development and Housing (Behörde für Stadtentwicklung und Wohnen, BSW). The Urban Workshop is one of three partners in the research and development project DIPAS. The other two are the Agency for Geospatial Data (LGV) and the CityScienceLab of HafenCity University (HCU). While the Urban Workshop coordinates and manages the project, the LGV is in charge of providing necessary GIS systems and data management, while

– with support of the HCU – the LGV carries out software development and implementation. The HCU, in turn, is in charge of scientific monitoring and evaluation of the system.

The DIPAS system has been developed during a three-year research project between BSW, HCU and LGV, from 2017 to 2020. Technical development takes place in three development phases, and each phase is accompanied by a usability and user-experience study to evaluate the user interaction with the system in order to re-inform further development and assess the system's effectiveness. This research concluded at the end of the second development phase following the completion of the subsequent second scientific evaluation.

The basic requirement for a digital participation system is a comprehensible and reliable presentation of information such as public data, documents, and plans; the system must also provide a visualisation of spatial data, plans, panning alternatives, designs and simulations (Lieven 2017). Additionally, it must provide a digital feedback channel leading to the institutions responsible for the planning and allow citizens to voice their thoughts, criticism, ideas and comments in connection with planning projects (cf. Lieven 2017). In order to reach this objective, the project brings together a workshop tool established within the FindingPlaces Project at HCU (Noyman et al. 2017) and an online participation tool established by the Urban Workshop. Both tools are integrated over a digital interface that can be operated through physical tools: citizens can participate either online, from a remote desktop or smartphone, or onsite, in participatory events. The digital workshop tool is designed to present citizen comments and other maps and georeferenced 2D data on a large touch screen application. This browser-based application is an extension of the existing online participation tool. The graphical user interface (GUI) consists of the following elements: an interactive 2D map, an address search bar, a comment menu to show / hide citizen contributions of different categories, a layer menu to show / hide geodata layer, and a system menu with setup functionality, such as full-screen or lock-screen. The 2D map displays the geolocated comments and the geoinformation layer and is freely navigable. The position of the map usually shows an overview of the district / area that is being discussed in the current participation process. With the help of this digital workshop tool, citizens can access geospatial information and other services, discuss with other citizens and planners onsite and input their comments into the digital system. DIPAS can thus be classified as a softGIS tool as it visualizes localised knowledge through user-friendly digital tools (Kyttä and Kahila 2011).

The methodological design of DIPAS follows Arnstein's aforementioned ladder of participation and aims at facilitating processes of information, consultation, involvement and collaboration (Lieven 2017). Citizen contributions are usually characterised by a broad and heterogeneous range of topics. A thorough treatment of these written comments is key in order for the participatory process to unfold its effects. The analysis of these contributions has so far been done by contracted service providers, oftentimes on-the-spot. The increasing amount of participation data is a challenge. In the DIPAS system, this issue is addressed with the integration of a natural language processing tool (NLP) to analyse the citizen comments and perform an extraction of key topics, opinions, and valuations. DIPAS is set out to support complex participation processes online and onsite on the basis of available data and knowledge. The seamless integration into public data infrastructures and administration processes is a key element (Lieven 2017).

3.3 The Dimensions of Participation

3.3.1 The Participation Cube

This paper is methodologically rooted in Fung's (2006) concept of the three dimensions of participation: the selection of participants, the modes of communication, and decision making and the extent of authority and power. Fung set the framework to analyse participation procedures in a visual figure, the *Democracy Cube*. He aligns the three features along three axes with scales. Mapping a participatory event within these axes creates a three-dimensional space visualising the characteristics of each approach. These characteristics are: (1), selection of participants, (2) modes of communication, and (3) the extent of authority and power.

3.3.1.1 Selection of Participants

Put shortly, the first aspect addresses the threshold for participation. Research has pointed out that high thresholds exclude already marginalized groups such as migrants and people with lower sociocultural resources (Kast 17/2008; DIFU 2003), pushing them even further to the edge of having a political voice (Behörde für Stadtentwicklung und Umwelt 2013). Brown (2017) points to the increased significance of local populations that are affected by planning decisions. This emerges as a key question for e-participation over the past years: can e-participation help broaden outreach not only in absolute number, but also in terms of inclusiveness of otherwise difficult-to-reach communities?

As Fung (2006) outlines, participation of citizens can remedy a lack of knowledge, competence, public purpose to command compliance and cooperation. But the success of participation processes heavily depends on who participates; whether the subset is representative of the relevant population, whether important interests are included, whether participants possess information to make good judgements, and whether they are accountable to those who do not participate. The important questions thus are, according to Fung (2006): Who is eligible to participate, and how do individuals become participants?

This study includes additional questions regarding the possession of information: What knowledge do participants bring to the workshop, and what information do they obtain during the procedure?

To scrutinize the inclusiveness in the selection of participants, Fung's *Democracy Cube* shows a diversified definition of the public. Running the scale from *more exclusive* to *more inclusive*, the cube lists Expert Administrators – Elected Representatives – Professional Stakeholders – Lay Stakeholders – Random Selection – Open, Targeted Recruiting – Open, Self-Selection – Diffuse Public Sphere.

3.3.1.2 Modes of Communication

The second aspect responds to the mode of communication. Depending on the design of the participation procedure, the range of modes of communication and decision making can vary from purely conversational modes where citizens can express and exchange concerns and preferences, towards more deliberative modes, where individual choices are exchanged and mutual agreements are established (Granberg and Åström 2010, Behörde für Stadtentwicklung und Umwelt 2013; Healey 2003).

Main questions regarding the mode of communication are: Are preferences of citizens explored, developed and possibly transformed during a collective deliberation procedure? Are citizens' opinions translated and aggregated so they voice one collective choice instead of listing individual preferences, mediating the influence and power they bring towards officials? (Fung 2006, S. 68-69). These questions focus on characteristics such as the communication during events, the connection of relevant stakeholders and the aggregation of voices. As the modes of communication unfold the possibility to act creatively, so does the intensity of their influence. Therefore, the *Democracy Cube* arranges the modes of Communication range from *least intensive* to *most intense*: Listen as Spectator – Express Preferences – Develop Preferences – Aggregate and Bargain – Deliberate and Negotiate – Deploy Technique and Expertise.

3.3.1.3 The Extent of Authority and Power

The third aspect regards the scope of the procedure and the authority in decision making. Research has shown that although participatory processes are increasingly employed, they usually lack anchoring within democratic structures (Allianz Vielfältige Demokratie 2017). Especially when the procedure appears closed rather than open and unbiased, the unfolding power might be perceived as limited, which can lead to frustration and can harm trust in democratic and participatory procedures (Bertelsmann-Stiftung 2010). Aspects of this feature include communicative influence, altering or mobilising public opinion, and decision making, the level of influence on authorities as well as the transmission of citizen comments to planners and the integration of the participation into formal planning procedures.

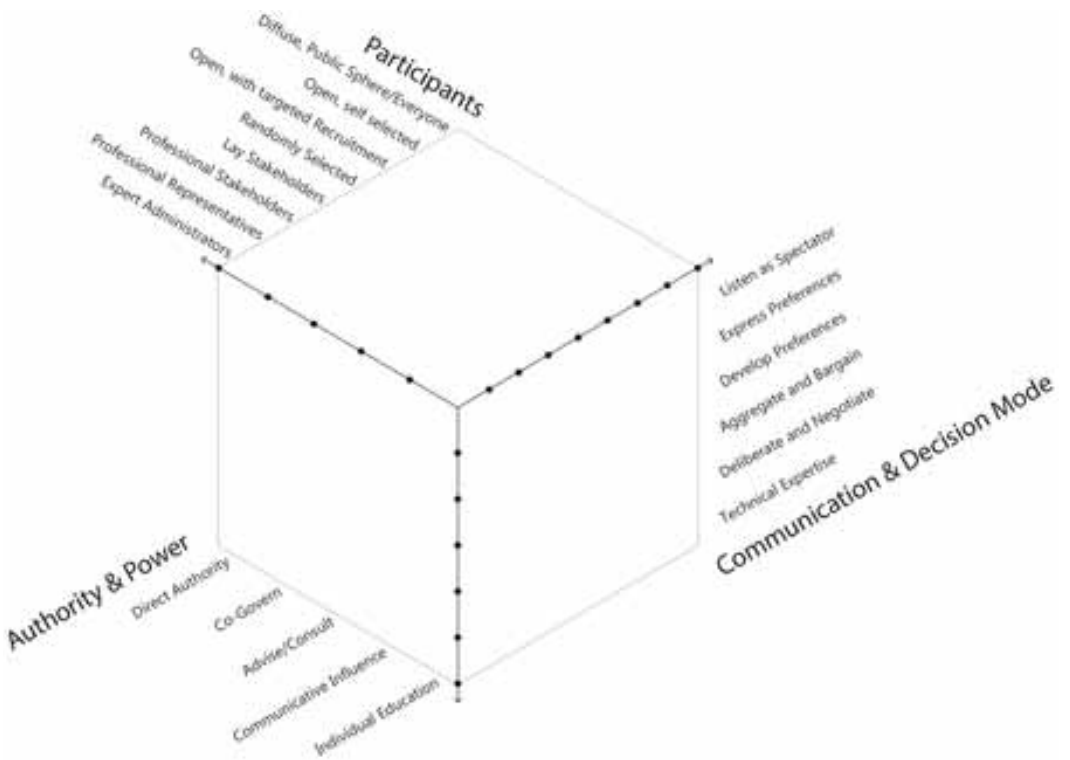
In order to assess the level of authority and power, the *Democracy Cube* aligns the extent of this aspect from *least authority* to *most authority*: Personal Benefits – Communicative Influence – Advise and Consult – Co-Governance – Direct Authority.

The present contribution suggests an update of Fung's *Democracy Cube*. From the root of the matrix to the outlines, and summarizing the sections developed above, Fung aligns the features in this way: participants from *most exclusive* to *most inclusive*, communication from *most intense* to *least intense*, scope from *most authoritarian* to *least authoritarian*. He then inserts different formats of participation into the matrix according to their characteristics within the three key features. The higher a procedure is characterized in terms of communication and scope, the closer it is situated at the root of the matrix. For the participant selection, this order switches: the more inclusive the participant selection, the further away this procedure will appear from the root of the matrix. While this tool allows for a spatial array of formats and therefore offers analytical clarity, it stays below its possibilities as a tool for visual analysis, as it lacks expressiveness in terms of the expansion in scale. This research introduces a variation of the *Democracy Cube*, for better distinction called the *Participation Cube (Figure 1)*, which aligns the three dimensions differently, namely: from lowest intensity of a feature to most. This allows for the same clarity in analysis but has the benefit of creating a visual representation of the level of openness, influence and complexity. As the three-dimensional space that is created grows, the more characteristics are fulfilled.

3.3.2 Data Collection and Analysis

In order to measure the impact of DIPAS, this paper aims at comparing the three formats of online, onsite and integrated participation by analysis with the *Participation Cube.* Due to the abundance of methodological setups for participation procedures (Nanz and Fritsche 2012), the comparison of

Figure 1. The Participation Cube (Source: author, adapted from Fung 2006)



the three modes of participation is a challenging task. In the following, the empirical data analysis is constrained to the evaluation of the integrated DIPAS system, while the evaluation of onsite and online procedures is taken from theoretical publications. This limits the explanatory power of the analysis as it only allows for experimental data for the integrated system. However, this research can thus operate as a starting discussion for future work on this topic.

The data for the evaluation of the integrated system stems from the empirical study that is carried out to support the technical development of DIPAS during the project runtime between September 2017 and August 2020. DIPAS is set out to be developed in three phases: a first Minimum Viable Product was rolled out in early 2018, and a second, upgraded product with more functions in early 2019. The development is accompanied by extensive research during each phase. This paper concentrates on the outcomes of the first two development phases.

The planners' perspective was assessed during a longer, standardised yet open interview that was held in November 2018 at the planning authority after the first phase of the development plan had been completed, and at the end of the first development phase of DIPAS. The two planners had been responsible for developing a new concept for development of the district of Bergedorf and had run a comprehensive participation procedure in onsite workshops. During these workshops, the baseline DIPAS system was piloted and approximately 120 visiting citizens were able to test the DIPAS workshop tool. Additionally, the authorities ran an online survey where citizens were able to contribute. 471 comments were collected via DIPAS. The remarks, ideas and questions were analysed by a contracted office who organised the parallel running analogue workshop and sent the results back to the public planners.

The user perspective of citizens was assessed with (A) a Usability and User Experience study in a laboratory setting, (B) piloting workshops during real participation procedures accompanied by short semi-structured interviews. During these events, questionnaires were handed out to participants assessing sociodemographic data such as age, professional background and residential area to allow for the evaluation of the diversity of included stakeholders.

(A) As the controlled setting of the study allows for more insights into the potential of the system, the analysis focuses on those data. However, it will be contrasted against findings from the piloting event, as this allows for insights into events that are more subject to spontaneity and improvisation. The Usability and User Experience study was held in three consecutive workshops in April 2019 with each 6-9 participants of all age groups, 24 participants in total. They were invited through newsletters of the Agency for Planning and Housing (BSW), the Hafencity University, and personal networks. The study took place in the building of the BSW during the early afternoon and evening, to allow people with family or work responsibilities to participate. Each workshop lasted 1.l5-2 hours each and was designed according to standards in sociological research on e-participation (for details on these standards see Baur and Blasius 2014; Bargas-Avila and Hornbæk 2011; Große 2018; Seaman 1999; Schrepp 2019). In three phases, the citizen's interaction with the tool was studied by participatory observation and a group discussion.

(B) The piloting at the kick-off event for a development plan (Kleiner Grasbrook) happened in December 2018 at an informational event and a subsequent workshop where the system was piloted in a local community café. Approximately 100 people were present, the majority of whom had a professional interest and approximately one fourth were residents of neighbouring areas (this was asked during the welcoming phase). Interaction was observed and short standardised interviews were held with randomly selected participants.

All observations were protocolled by staff of HafenCity University and the group discussion and short interviews recorded and transcribed using an online tool. The documents were imported to MaxQDA, coded and analysed. The coding and analysis of data followed the principles of a structured content analysis (Mayring and Fenzl 2014). The method was established in the 1980s to facilitate qualitative analysis of big data sets. Because this methodology generates categories, it demarcates from other text analysis tools. The category system structures the data and thus allows for more than

a free interpretation, but a thorough and rule-governed analysis that allows for intersubjective review (Mayring and Fenzl 2014). With the aid of this methodology, latent content can also be discovered from the data, and the qualitative insights can be analysed statistically. The first evaluation phase of the DIPAS system brought about 178 codes with 1105 coded parts in the data. The second phase brought 184 codes with 527 coded parts. These have been used in the analysis of Usability and User Experience and fed back to the developers of the project in comprehensive reports.

Next to an analytical discussion of these values, this chapter will visualise the arguments by drawing three-dimensional spaces within the matrix of the Participation Cube, each for the online and onsite processes, thus visually representing the extent of one participatory process compared to another. This research aims at understanding the impact of an integrated participation procedure as it combines the benefits from online and onsite procedures. This will be measured by laying the three-dimensional spaces on top of each other and analysing the resulted added or reduced spaces as a visual representation for added value.

4. RESULTS

4.1 Participant Selection

4.1.1 Acquisition of Participants

Onsite procedures rely heavily on the time resources of citizens and their verbal strength to persist in group discussions. Thus they oftentimes result in a homogenous group which is of above-average age and disproportionately male; often excluded are immigrants, people with young children or people with work obligations (Lieven 2017). Online procedures are likely to have a higher inclusivity as they are less bound to time and space and can be accessed anytime from anywhere. However, relying only on online participation could also have segregative effects, as Lieven points out: "*A digital divide persists along the lines of age, income and education. (…) When developing tools and methods for digitised participation, such segregation effects need to be taken into account, and counter-strategies need to be developed*" (Lieven 2017, p. 2478). The least restrictive method to select participants is open participation, where participants are self-selected. In the case of the DIPAS piloting event, participation was open to all. But when the audience at an event was asked about their background, only a small subset of people identified as neighbours of the development lot, while the majority was associated with the planning authorities or development companies, or represented other stakeholder groups such as members of initiatives or local commerce. This proves that those who choose to participate are frequently not representative of the larger public, and emphasis is on those who are wealthier and better educated. This could not be changed by the integrated system: People showed a lot of interest in DIPAS, but they were not well-informed about it. One participant emphasises that the system provides a great opportunity for citizens to participate, however it lacks advertising:

I think it's great that there's an online platform because there are always people who do not have time to attend the evening events for a variety of reasons. Because they cannot leave their workplace, or they have to be with their family at that time and so on. So now they have the opportunity to participate. However, what I've already thought about it on the way here, that it has not been widely promoted, so that all the people here in the district could know about it. So you have to lower the threshold in some way, one should sit down in the men's cafés and women meeting places. (Executive, 49 years old)

The question of adequate promotion of participation events is a topic that was not addressed within the research project but remains important. Participation processes, in practically any case, depend on skilful publicity and promotion strategies (Zentraler Immobilien Ausschuss 2013).

Having jumped the first threshold of *knowing about the event*, not all participants who were present interacted with the system. It has been established earlier that workshop settings privilege

those who are verbally strong and do not mind speaking up in a group of people, thereby excluding others. This dynamic has also been observed with the digital system. However, the issue of verbal strength seems to be less pronounced because the digital touch surface allows for participants to interact directly with the tool and add comments without having to speak up. On the other hand, the digital tool creates a divide along another line – between those participants who feel comfortable interacting with technology and those who do not. As one female participant puts it: "*I don't dislike it [the table tool]. It is just strange. One does not know what it is and might be a bit hesitant before approaching or interacting with it*" (Employee, 44 years old).

Here, the comparison between the piloting workshop and the study setting is significant: Compared to the piloting workshop, where oftentimes participants were observed walking past the tool, watching but not interacting, people showed immense interest to interact during the study. Because the study was characterised by the invitation to use the tool and a facilitator was present to support and encourage interaction, participants apparently felt more comfortable using and playing around with the technology. A conclusion for future uses of this tool emphasises the importance of an encouraging setting and the strong effect of the table facilitator.

4.1.2 Level of Information

When interacting with the different layers of spatial data in the workshop tool, participants reacted in a positive manner: "I found the interaction to be fun and rather innovative" said one participant. The visualisation of geospatial data facilitated high-quality discussions, and people appreciated the availability of data. The integration of quantitative data provided by the authorities with the local, qualitative knowledge of citizens' input – the softGIS – acted as support in extensive discussions.

Comparing onsite, online participation and the integrated DIPAS tool, characteristics on the scale of participant selection differ. Due to resource restrictions of onsite procedures, these would point to the characteristic open, self-selected participants, while online procedures allow for a diffuse public sphere and allow (almost) everyone to participate. DIPAS integrates an online tool in the public participation procedure and thus includes the diffuse public sphere. Thereby, DIPAS achieves the most inclusive participant selection mode (see visual analysis at the bottom in Figures 3-6).

4.2 Modes of Communication and Decision Making

The classical perception of onsite participation procedures is marked by lines of citizens waiting at a microphone in order to express their preferences towards officials. Communicative participation procedures have altered this by designing settings in which citizens can inform themselves on planning procedures, discuss in groups the advantages and disadvantages and voice their opinions. Depending on the mode of the procedure, it can result in a higher degree of aggregation of voices as the events oftentimes allow and even ask for group discussions on topics. Online commentaries are, due to the singularity of an online user, deemed to arise out of a single mind. However, as oftentimes tools showcase the contributions in online maps or lists, contributions experience a higher visibility and thus transparency. Online procedures additionally have the advantage of being connected to public data, allowing citizens to request information in real time, showing spatial data according to the questions that arise during the procedure, before writing a remark or commentary in order to make a more informed choice. In comparison, the knowledge base at offline onsite events is more limited and dependent on preparatory work by those implementing the procedure.

In the Usability and User Experience study as well as the piloting event of DIPAS, a high level of collaboration has been observed and voiced, while users additionally retrieved the available data to underpin and qualify discussions. In one discussion on the future use of an old building in the planning area, two users launched into a discussion on how to include a local rowing association into the development of the area. By retrieving information on historical and preserved buildings, the two users developed the idea of using the historical building that is situated directly at the waterfront as a storage facility for the rowing boats and input this idea into the system. Another user pointed out:

I really liked this about the table, that we sat there together and talked about the topic, and I notice: Oh, I am really interested in what the others have to say. I like that, and I wouldn't have thought that a table can do that. (Student, 32 years old)

This exemplifies the quality of interaction of onsite procedures that is supported by geospatial data that can be solicited individually when needed – a feature that is usually only available in online interfaces. DIPAS thus enables collaboration facilitated by technology – opinions are exchanged, preferences explored and possibly transformed through the solicitation of data, and new group preferences are communicated to officials via the contribution form. Decisions on what to write in a comment are made individually or in small groups. Contributions can also be voted and commented on, allowing not only for verbal onsite communication, but also for discussions online.

Comparing the online vs onsite DIPAS procedures in this domain, results highly vary. Whereas online procedures oftentimes are reduced to allowing citizens to express their preferences via online forms but not to engage over content, onsite procedures allow engagement about content but transmit preferences in their singularity as they are collected as notes, analysed on-spot by facilitators and presented in an aggregated way during the event and possibly in further reports. Online procedures can then be sorted into the characteristic *expressing preferences*, while offline procedures would dwell at *developing preferences*. DIPAS can be sorted into the characteristic of *developing preferences* as well, but the system does allow modes of deliberation and negotiation as well. DIPAS enables social choices to be communicated to officials, and has the significant benefit of allowing comments and remarks to be made any time of day from any location thus increasing scope and lowering thresholds for participation. But since DIPAS does not increase power in decision making, the system is still situated within the lower, communicative ranks of the scale.

4.3 Extent of Authority and Power

4.3.1 Transmission of Citizen Contributions to Planners

In onsite procedures, questions of transparency emerge regarding the impromptu analysis of comments by hired facilitators that cannot be held accountable by public vote. Online tools yield the power to increase transparency as they can showcase all contributions and make the data available to the public. However, as onsite procedures are well established, there are procedures for including citizen remarks from participation events into the formal planning procedures. It remains to be seen how this holds true for online procedures: the increased amount of data calls for a higher analysis effort and pulls more resources as the scope of participation increases. Here, online participation holds a key question: How should the upcoming big data in participation procedures be analysed? And how can transparency be achieved in the analytic procedures that eventually lead to decisions and preferences? Lieven sees the complexity of contributions as a key challenge and the meaningful restructuring of them as a main feature (Lieven 2017).

Another characteristic is the evaluation of contributions. What happens with the comments, who is evaluating and analysing them? How are they implemented in the planning process? In the first development phase of DIPAS, entries were output in an excel file and handed to the planning authorities. These were then been forwarded to the external service providers, "and they came up with a way to interpret the results" (planner). Due to restrictions in the resources of public authorities, the most sensitive task, the qualitative analysis, had been handed to external parties. In addition to the above-mentioned issues of lack of transparency and accountability, planners voiced their expectation that DIPAS would analyse and evaluate citizen comments. A reporting function has been elaborated on additionally:

If you could export data from the table to other programs, or automatically create a PowerPoint that you can present at the end of the day, or make screenshots and document intermediate results. An

interface to other digital possibilities, so you can save time for extra documentation. If I could wish for something, it would be that. (Planner)

4.3.2 Integrating the Results of Participation Procedures Into Formal Planning

Most communicative procedures address informal participation. As there is no legal obligation, citizen contributions remain only recommendations and do not develop authoritative power. This topic will be expanded on in the closing analysis.

Onsite procedures, as outlined above, can develop *advisory/consulting* characteristics, however the extent of this depends highly on the quality of the workshop and openness of the planning process. Online procedures hardly move beyond the mode of *communicative influence.* As DIPAS provides valuable mechanisms of collaboration and aggregation of voices, it can be sorted into the medium characteristics of this scale, *advice and consultation*:

In this mode, officials preserve their authority and power but commit themselves to receiving input from participants. The stated purpose of most public hearings and many other public meetings is to provide such advice. (Fung 2006, p. 69)

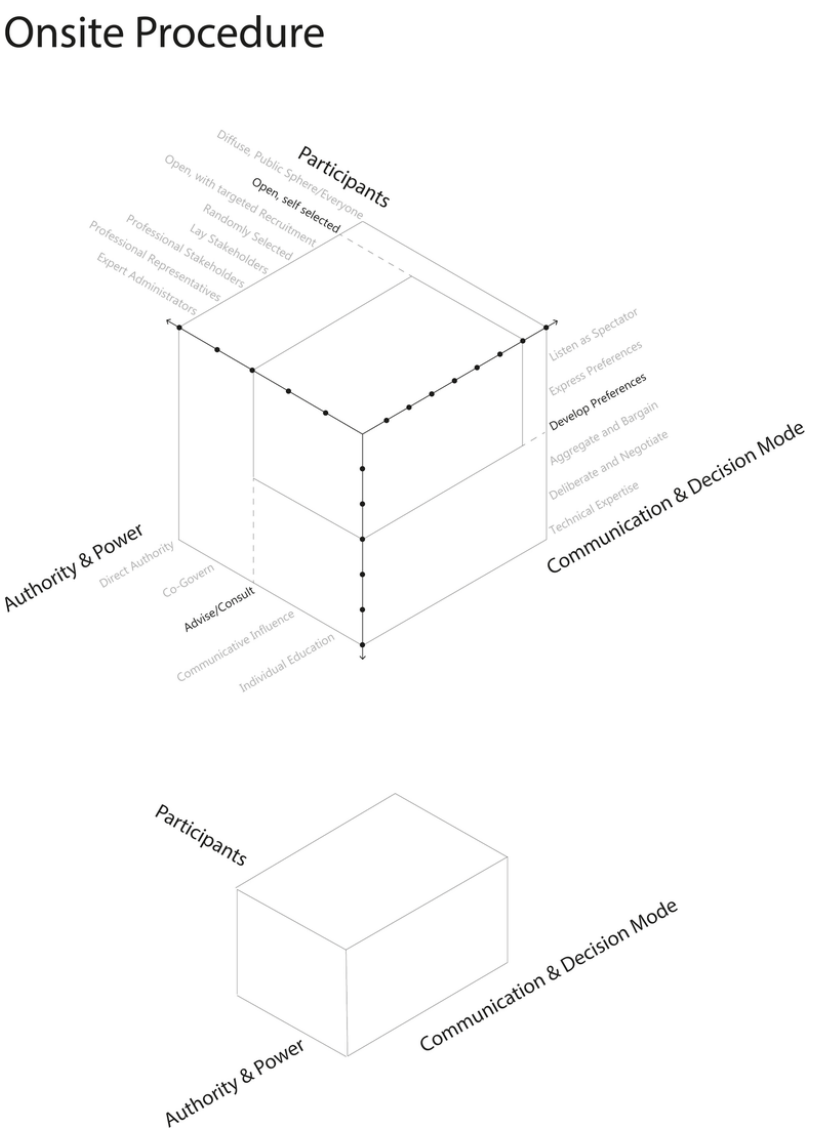
4.4 Comparing the Three Procedures

The visualisation shows that onsite procedures have a higher capacity in developing authority and power while employing more complex modes of communication and decision making compared to online procedures. The latter, however, invite a larger audience of participants compared to onsite procedures (Figures 2 and 3).

The comparison has shown that DIPAS as an integrated procedure combines the benefit of both approaches. It allows wider audiences to participate in the procedure by offering remote tools for participation typical of online procedures, but it also invites participants to engage in discussions both onsite and online, thus enabling citizens to exert advisory and consulting authority in the procedures (Figure 4).

DIPAS combines the better of both approaches, adding to each discipline a benefit from the other. This argument can be visualised with the Participation Cube by laying the three-dimensional spaces on top of each other and analysing the resulted increased added spaces (Figure 5). What this shows is that DIPAS has indeed an added value. This value stems from two main aspects: the aggregation of higher numbers of citizens and the communicative effort undertaken during onsite events. By inviting more citizens to voice their preferences via the online contribution tool, and at the same time enabling qualitative discussions and collaborative tinkering with the use of the digital workshop tool, DIPAS allows for a more diverse, higher-quality set of comments, ideas and remarks. This alone is not an added value, but the outcome of combining the advantages of both tools is. What arises out of this combination though, has implications for the political legitimacy of the participation procedure. All comments are publicly available on the DIPAS website, whichh offers a basic evaluation of comments according to topic, number of comments, and number of positive reactions from the community. This provides greater transparency since the public can access the results of the participation process. Unlike onsite procedures, no translation and mediation is carried out by external service providers, while at the same time the complete datasets of entries are publicly available for each citizen to access. This hands over control of the decision-making process. Because the extent and content of public opinion can be viewed by all, citizens are able to track which ideas have been incorporated in the planning decisions, and can hold their authorities accountable for their decision making.

Figure 2. Analysis of onsite procedures (Source: author, adapted from Fung 2006)



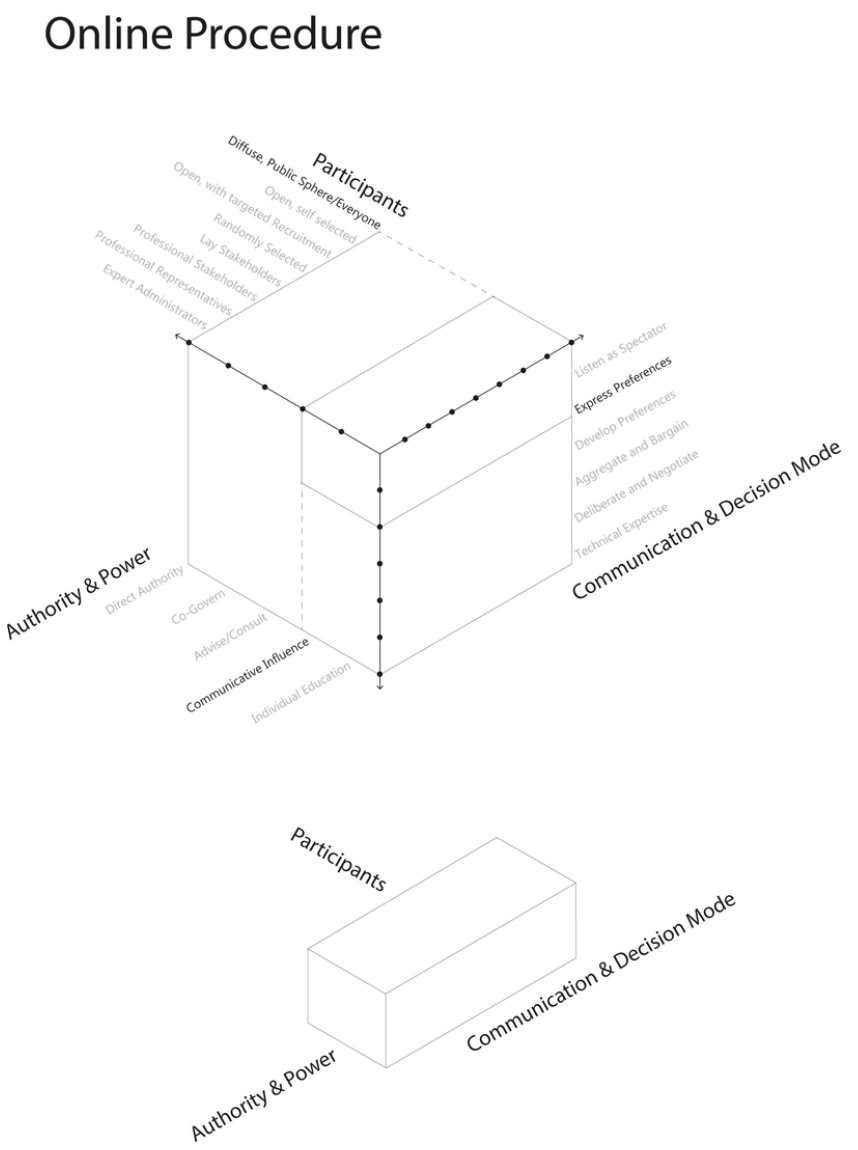
5. DISCUSSION

Questions remain regarding (1) the transparency of communication, (2) the diversity of participants, and (3) the integration of communicative participation in administrative processes and institutions.

5.1 Transparency in Communication

Up to now, no process has been established for how planners in the respective authorities are to integrate the findings from DIPAS tools into formal planning routines. Technical and administrative path dependencies certainly distort the potential uptake and utilisation of results. In the DIPAS project/study, all entries were collected, analysed and interpreted by a service provider specialising in public participation procedures. Their analysis was collected in a pdf document and sent to the planning authority, where remarks were clustered according to topics, with short summaries for each thematic

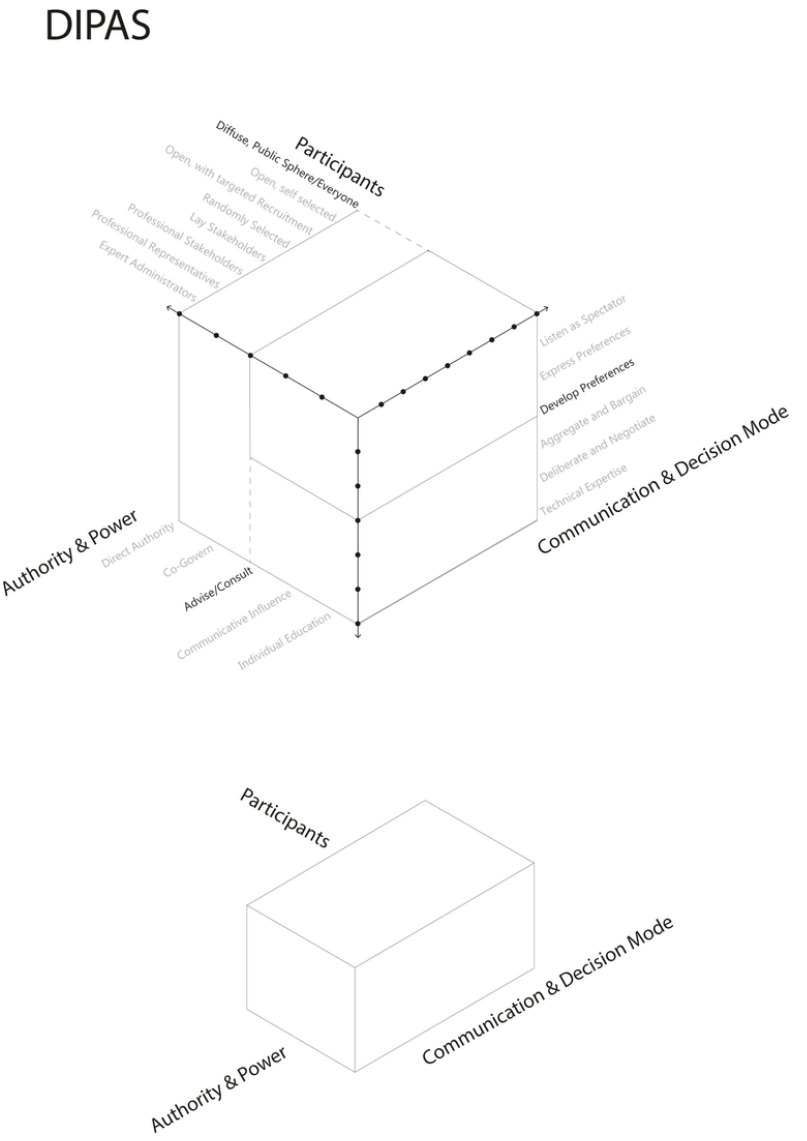
Figure 3. Analysis of online procedures (Source: author, adapted from Fung 2006)



cluster and main remarks indicated. The authority then developed a publication on the basis of this analysis. This process invites criticism: not only is the methodology of this process not transparent, it is also conducted by a private company, and thus lacks the level of accountability required of elected representatives. The possible influences of subjectivity in the aggregation of citizen comments is a topic for discussion. Additionally, by aggregating voices, the individual comments disappear from the discourse. This exacerbates later reviews of planning procedures because the historical data of past participation procedures is not accessible by the public anymore.

Greater transparency could be provided by variations on the moderation of these events, or by providing a direct channel for citizens to communicate their preferences. However, the review of these communications might overwhelm available resources at the public authorities. Within the DIPAS project, this challenge has been taken as a motivation to work on an evaluation tool that pre-clusters

Figure 4. Analysis of DIPAS procedures (Source: author, adapted from Fung 2006)

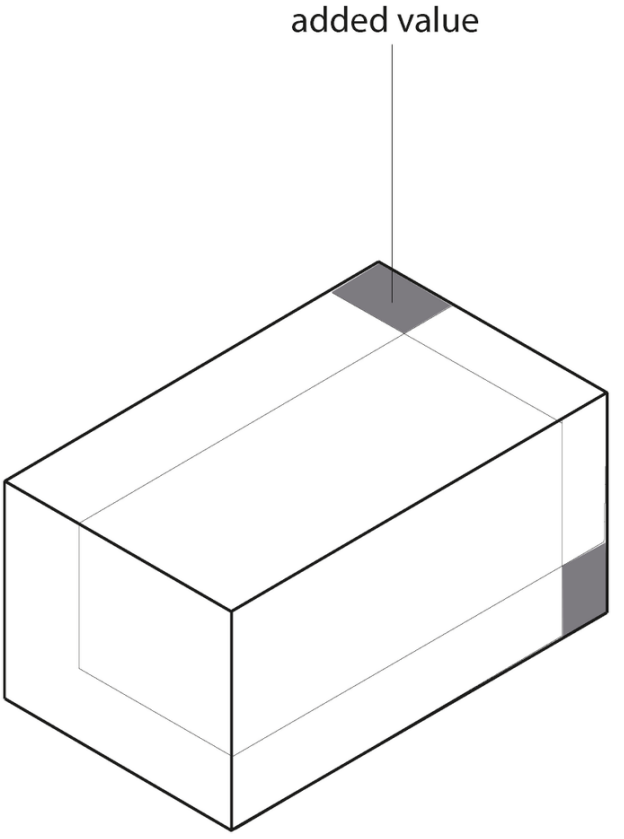


entries and extracts key topics based on mathematical functions. The advantage of automatically evaluating contributions is increased transparency and the aggregation of voices: if the knowledge about the amount citizens' real-time and historical interest in a specific topic is publicly available, it might create added pressure on officials to regard those voices in further planning. This would be content for further research. However, the development of an algorithm-based semantic analysis of citizen commentaries raises questions regarding the modes of decision making characteristics of these algorithms and has to be observed critically.

5.2 Diversity of Participants

Another aspect that could not be addressed within this study is the extent of diversity that the online participation tool, the one that DIPAS is integrating with the workshop tool, enables individually.

Figure 5. Added value (Source: author, adapted from Fung 2006)



This is due to the decision to let users comment without having to sign up, create an account and input personal data. A quantitative comparison of sociodemographic participant data in onsite and online participation procedures is required in order to determine whether the use of online tools increases diversity of participants, or if a digital divide appears/is evident, thus hindering certain groups from engaging. This would allow for insights into the performance of integrated systems such as DIPAS in this matter, and whether the combination of online and onsite procedures results in greater diversity in participation audiences.

5.3 Integration of Informal Participation Into Formal Planning

The new participation paradigm calls for a change not only in the tools used, but also in the culture of participation (Silva 2010). As has been elaborated, informal participation lacks political obligation and thus is limited in the extent of authority it enables. Within DIPAS, technical integration of the new software into existing and already operating technology is an objective – thus allowing for a lower threshold in the translation of knowledge from informal procedures into formal planning. This is being reached by two cascades in development. As a basis, the new software is developed within technological frameworks that are already in operation within the municipality to allow for easier maintenance and integration into existing systems. In a second step, the project aims at integrating the system into the digitised process chain that spans from the creation of first concepts until the approval of zoning plans, thus allowing planners to seamlessly access information from informal

procedures while working on their system and re-incorporate the results into the ongoing planning process. These questions could be addressed in further research on the DIPAS system.

6. CONCLUSION

This paper's objective was to assess the impact of an integrated participation system by utilising the *Participation Cube* for the evaluation and visualisation of empirical data. The research presented thus enriched the scientific discourse on participation by arguing for a complex view that integrates aspects beyond the *level of participation*. By giving an empirical example, an argument was made for a less normative view on the evaluation of participation since the highest form of citizen power might not always be the ideal decision mode. The design of participation procedures should be handled with care towards the abovementioned aspects and to the context and institutional framework in which the process is taking place. This paper introduced said Participation Cube, but further research should specify and detail its indicators.

By answering the research question, the added value of an integration of online tools with onsite participation procedures was highlighted. It was found that participants, being invited to discuss with others face to face, were engaging in discourse and collaboratively developing planning ideas, which they would then suggest. Compared to simple and singular online commentary, the heightened quality and depth of these contributions points to the importance of working with digital tools in moderated onsite settings. Future research should look into the content of these statements and analyse whether the quality of argumentation and level of innovation increases with the use of integrated systems.

A second finding highlights the importance of facilitation during these events: as this research has shown, participants were more likely to engage with the digital tools when a facilitator was present to encourage interaction with the tools – especially in the presence of people who self-claimed to have less experience with technology. This finding supports a counter-argument to a deployment of technological tools for public participation without further physical human interaction as the technological threshold might exclude members of the public from interacting.

A third argument supports the critique voiced by others (Arnstein 1969; Miessen 2012; Mouffe and Wagner 2013; Rancière 2008) that the power of participation relies heavily on the extent of authority it develops. In the case of DIPAS, the presented research has shown that however thorough the results of communicative participation procedures might be, a lack of legal obligation lowers the impact. It is yet to be seen whether the technological integration of results from informal participation procedures into administrative technical systems could ease access to that information. This matter could be observed in further research after the implementation of such a technical intersection.

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ENDNOTES

1 A remark on wording: In this paper, participatory planning events that employ communicative methods are summarized under the term *onsite procedures*. Oftentimes, but not exclusively, these events do not utilize digital tools and will thus serve as counterexamples to the case study events that integrate communicative methods and digital tools.

2 For a detailed analysis of e-participation frameworks see Wirtz et al. (2018).

3 For an extensive overview see Nanz and Fritsche (2012).

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Complex arrival procedures as a challenge in migration studies: a comparative analysis of quantitative and qualitative methodologies within migration research

Rosa Thoneick, Marie Malchow, Ingrid Breckner and Jörg Noennig

Introduction

This chapter takes migration as a vantage point for its research and examines it from an urban perspective. The authors follow two antagonistic views on migration in contemporary European cities: the *conceptual urban*, characterised by organisational instruments such as master plans and policy instruments, vis-à-vis the *factual urban*, which arises as a result of the performative daily practices of migrant inhabitants (cf. De Certeau, 1988; Dell, 2016; Thoneick, 2018). By analysing the relationship between them, this chapter closes the gap between the quantitative body of work analysing societal border regimes, identity politics, as well as policy frameworks and the qualitative body of work shedding light on everyday practices of migrants within arrival procedures (cf. Çağlar & Glick Schiller, 2011; Yildiz, 2013; 2017; Breckner, 2018; Terkessidis, 2018; Diaz-Chorne, et al., 2019). This chapter thus broadens both research perspectives by making visible the multitude of practices and strategies migrants employ in order to overcome social stratification and border regimes in arrival societies. By doing so, it advocates for an integrative view on the performativity of everyday migrant experiences within formalised arrival systems (cf. Yildiz, 2017; Breckner, 2018; Terkessidis, 2018).

Migration has always been a constituting element of urban reality, bringing diversity, new perspectives and impulses to cities (cf. Massey, 1991; Yildiz, 2013; Cranston, 2017). Every third life story in metropolises is shaped by migration,

thus connecting local stories to global processes (cf. Yildiz, 2017). Migration and the diversity she brings about is not an exception to the rule or an imported phenomenon but a constitutive element of the urban and, thus, an integrative part of urban development (cf. Yildiz, 2017; Terkessidis, 2018). If we take migration not as an exception to the rule but as a vantage point for our research, we understand three criteria that characterise the urban:

- It developed historically in different ways depending on societal contexts;
- It is subject to constant change: of the built environment, the composition of its citizens and policy principles; and
- It emerges in the performativity of everyday practices as it is a social product (cf. Kemper & Vogelpohl, 2013; Dell, 2016; Lefebvre & Schäfer, 2016).

These criteria render the urban as a spontaneous, ever-changing, multi-perspective space: a space that is, at times, not easy to grasp, read and understand, and thus, not easily managed. Managing the urban experience has been the tendency of urban production, specifically architecture, spatial planning and policies, and cartography. Michel De Certeau describes the organising principles as threefold: by cleaning up messiness, by overwriting history with a paradigm of progress and by implementing major narratives of urban entities through singular characteristics, it makes the urban readable (De Certeau 1988, pp. 183–186). These dynamics mark the antagonism De Certeau coins "the conceptual city" as the collective management of the urban and its inhabitants vis-à-vis the appropriation by urban daily practice in "the factual city" (cf. De Certeau, 1988; Dell, 2016; Thoneick, 2018). The factual urban represents the spontaneous, performative, supposedly unorganised city that opposes the planned actions of a powerful ordering structure, as De Certeau writes: "A metaphorical and meandering city pierces the clear text of a planned and easily readable city"[1] (De Certeau, 1988, p. 182). This quote evokes the image of the city as a text that can be read. However, as De Certeau argues, everyday urban practices are not easily readable, and the performativity of urban space, in its supposed disorder, eludes the analysis.

How can we understand the unreadable, daily and meandering urban? Research with this aim has to approach such an objective by applying an openly structured, relational methodology that locates relations of signifiers, in order to allow for vagueness and indefiniteness within individual and societal ordering systems (cf. Dell, 2009; 2016; Arouna et al., 2019;). This allows us (1) to read the socio-historical and socio-structural prerequisites in order to understand contemporary social dynamics within cities, (2) to focus on the

dynamism of societal relationships and (3) to see societal relationships in cities not as irrevocably but as constantly changing due to human and institutional interventions and, thus, changeable (Kemper and Vogelpohl, 2013). By doing so, research enlightens the three aforementioned characteristics of the urban: historical diverse development, performativity and open-endedness.

We see the urban as an ever-changing entry point for the exploration of processes of restructuring and migrants' integral roles in these processes: migrants are residents of cities and actors within them, thus contributing to and contesting processes that shape social relations, urban economy, politics and culture (cf. Çağlar & Glick Schiller, 2011; Breckner, 2018). Understanding migration as a constitutive element of the urban means also acknowledging the diversity that this brings and, with it, the ambiguity, ambivalence and contradictions of the urban (cf. Yildiz, 2017).

This research makes use of the EU H2020 project MICADO to assess these focal points by comparing the datasets and results of the two main studies conducted during the initial research phase of the MICADO project. These were a systematic literature review (SLR) on migrant integration in Germany in the domains of health, housing, education, labour and participation, and a series of co-analysis workshops with migrants and members of non-governmental organisations (NGOs) working in integration management on the topic of challenges and experiences with integration and arrival procedures, specifically in Hamburg. They represent two diverse methodologies that approached the research field of migrant integration from different perspectives. As they focused on the same domains (health, housing, education, labour and participation), and the same locality (Germany/Hamburg), their results were comparable. Both sought to understand the challenges and hindrances in arrival and integration procedures. Within this research, those two bodies of data will undergo a comparative secondary analysis to develop an understanding of the insights that both methodologies generate within their narrow research questions. The aim of this chapter is to read and make visible the traces of everyday practices and to interpret urban transformation from the perspective of migration. By focusing on societal relationships within a migration context, this research sheds light on marginalised knowledge sources and shifts them to the core of the analysis.

To make an argument for the integration of quantitative and qualitative research methods in complex questions of arrival procedures and integration processes, this chapter asks "Which insights can be generated through the combination of a quantitative systematic literature analysis and a qualitative

co-creative methodology in order to shed light on complex arrival procedures?" In answering this research question, this chapter analyses the scope and content of the results from both the SLR and co-analysis within the MICADO research project. It looks at differences and gaps within both bodies of data and sheds light on the benefits of combining both studies. By answering these questions, this chapter offers insights into the gaps that open up in the interspaces of migration policies. Those consist of but are not limited to a mismatch between the availability of crucial information for arrival processes and actual access to this information. By shedding light on these characteristic gaps and the strategies triggered by them, this chapter emphasises the significance of an integrated investigation into complex urban arrival systems. B discussing the combination of these methodologies, this chapter concludes that research in the complex field of migration and integration benefits from an integrated approach that looks at quantitative data and policy levels as well as tacit knowledge and everyday practices.

Methodology

For this chapter, a secondary data analysis has been conducted using data collected in a research project. In order to answer the aforementioned research question, this section introduces the initial research project and methodology, and adopts a systematic secondary data analysis and comparative method in order to shed light on the research approach for this chapter.

Project overview: H2020 Project MICADO—Migrant Integration Cockpits and Dashboards

The case study this article takes a closer look at is a European research project in the field of migration and integration, which started in January 2019 and is currently ongoing until summer 2022. MICADO stands for *Migrant Integration Cockpits and Dashboards* and is part of the EU research programme Horizon 2020 being coordinated by the CityScienceLab at HafenCity University, Hamburg.[2]

The consortium consists of 15 partners from five EU countries,[3] including research institutes, public institutions and one small/medium-sized enterprise. The project aims to facilitate the exchange between three user groups, namely migrants, public authorities and engaged civic society, and ease migrants' access to regular social systems (housing, education, healthcare and labour) and

counselling services through digital services. MICADO will provide a technical solution, more precisely one mobile application and two browser applications, for the three user groups to make arrival and participation processes more efficient. Through these measures, the project seeks to lower the socioeconomic effort and expenditure on migrant integration, both for host economies and individuals. The overall goal of the project is to create a helpful tool for the arrival process of migrants that will be integrated into existing structures sustainably and will eventually be offered on an open-source platform to be transferable to communities in other European cities.

To ground the technical development of the three applications on a scientific base, the project group went through a thorough phase of fundamental research in the first year of the project. Firstly, an SLR in the context of migration research was conducted to identify gaps in the current research and be able to sharpen the future direction and approach of MICADO. Following this, co-design activities with two of the three user groups took place to find out about the crucial needs, wishes and ideas for the applications to be developed.

Systematic literature review in MICADO

An SLR is a secondary study of all the available evidence relating to a specific research question using a well-defined methodology and following specific steps (cf. Kitchenham & Charters, 2007; Ferreira da Silva Barros & da Silve Rodrigues, 2018). With the help of this methodology, the literature is identified, analysed and interpreted (cf. Kitchenham & Charters 2007). The most common reason to conduct an SLR is firstly to identify gaps in current research, in order to be able to suggest areas of further exploration, and secondly, to provide a reference bibliography to construct a state of the art in which to position new research activities (cf. Kitchenham & Charters, 2007; Ferreira da Silva Barros & da Silve Rodrigues, 2018; Diaz-Chorne et al., 2019).

The crucial steps for this methodology are a thorough planning of the review (defining the problem, the research questions and sources, the amplitude of the results, the selection criteria), the primary reading of the articles, the selection process and the reading phase (cf. Ferreira da Silva Barros & da Silve Rodrigues, 2018). The pre-defined search strategy helps a fair review be conducted while limiting systematic errors such as bias: it aims to synthesise a comprehensive body of knowledge, regardless of whether the studies comply with the preferred hypothesis of the researchers (cf. Petticrew & Roberts, 2006; Kitchenham & Charters, 2007; Booth et al., 2016).

In the context of MICADO, an SLR was conducted in the first year of the project, which provided a framework in the field of migration research and identified gaps in the current research that helped to sharpen the future direction and approach of MICADO. More specifically, MICADO aimed to (1) obtain a general picture of documents related to the integration process of migrants, asylum seekers and refugees; (2) study different associations and policies on migrant integration implemented in the last decade as well as their effectiveness, especially on sectoral policies in the fields of health, housing, education, employment and participation; and (3) identify individual characteristics and contextual factors positively and negatively affecting integration (cf. Diaz-Chorne et al., 2019). In connection to these research objectives, a list of search terms was predefined and used as a search filter. For the SLR, all articles in the database Web of Science from the last five years were selected and supplemented with local and national reports from the main organisations dealing with migrants and refugees for all four partner cities of the project (Antwerp, Bologna, Hamburg and Madrid). For Hamburg, the final outcome was 176 documents that went into screening for eligibility. 70 papers were selected for the actual SLR, plus six national and local reports (Figure 1). This body of literature was read and analysed according to the predefined research questions regarding integration challenges in the domains of education, healthcare, housing, labour and participation. Within the literature reference system, each text was then labelled according to its scope, methodologies and specific characteristics to facilitate the process of analysis. These labels were used as codes for this research. This was done by two researchers over the course of five weeks and fed into a local report that was compiled into a thorough project-wide report (cf. Diaz-Chorne et al., 2019). For this analysis, the initial body of 70 papers is used as the data source.

Co-creative practices in MICADO

Co-creative practices[4] can be described as a methodology that focuses on participation in the design process with the goal of working on meaningful solutions (a tool, product, service or policy) in a group of diverse stakeholders using collective creativity tools (cf. Stembert, 2017; Apers et al., 2019). It is important to note that co-design "goes beyond consultation" (Sanders & Stappers, 2008, p. 5) and considers users as experts of their own experiences, hence they become a crucial and active part of the design process (cf. (Ventura & Bichard, 2017).

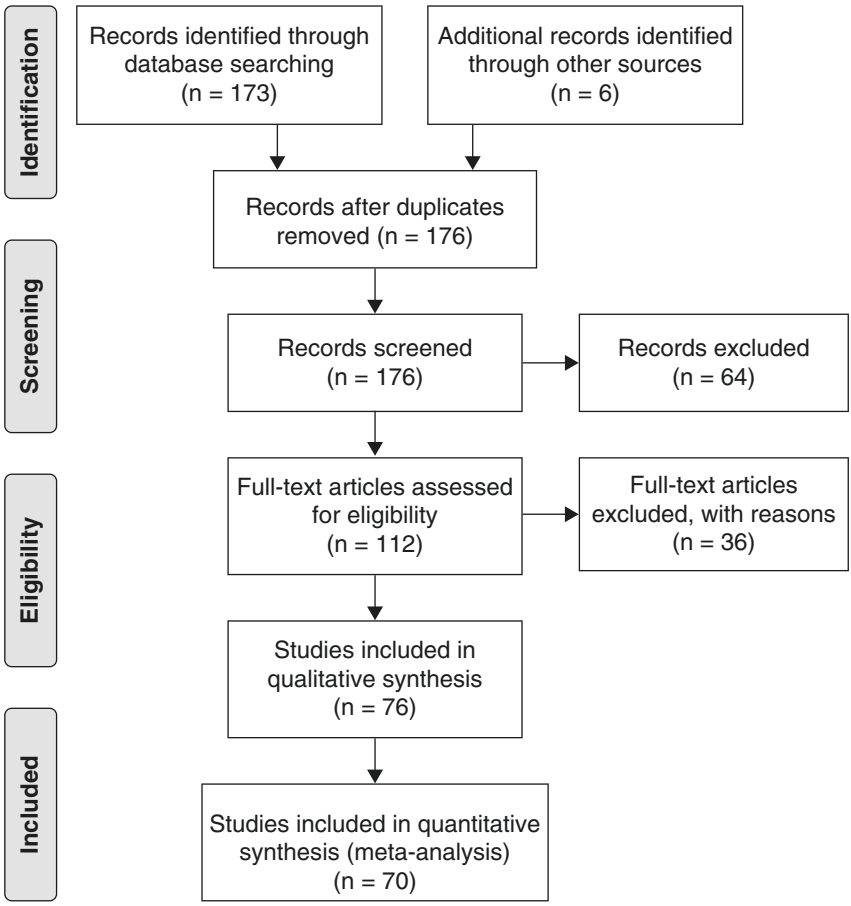

Figure 1. Prism graph of SLR body of literature and filtering process (Diaz-Chorne et al., 2019).

One main benefit of co-design is the understanding that different levels of knowledge can be accessed by different methods and that co-design practices are more sensitive to the latent and implicit needs and wishes of their participants than other methods. Additional reasons to use co-design practices range from the possibility of establishing a connection between groups that would not normally collaborate, to creating a common understanding and safe spaces for sharing, to empowering minority perspectives (cf. Sanders & Stappers, 2008). On a broader scale, Sanders (cf. 2013) emphasises that designing a sustainable future is only possible in a collective process.

It is important to acknowledge that during a co-design process, large amounts of qualitative data are generated, which need to be analysed thoroughly according to a defined plan afterwards (cf. Stembert, 2017). The success of co-design processes highly depends on a number of predetermined settings that are crucial to keep in mind. One aspect highlighted by Levi (2008) and Sanders (cf. 2013) is how the physical space and environment in which co-design workshops take place are created (small/large, close/distant from daily lives, welcoming/not welcoming etc.). "Building a healthy environment for co-creation" (Sanders & Stappers, 2008, pp. 7–8) is also one of the eight guiding principles suggested by these authors for conducting meaningful workshops. In addition to the factor of (1) the right environment, they highlight the importance of (2) a well-trained and skilled facilitator, (3) a clear definition of the needs of the target group, the aims and the tasks, (4) involving all relevant stakeholders, (5) developing a common value and vision during the process, (6) involving stakeholders at the right stage of the process, (7) being able to handle upcoming conflicts and varied interests and (8) reflecting and considering feedback on the whole co-creation process afterwards.

In the H2020 project MICADO, the first two phases of co-creation, namely co-analysis and co-design (cf. Stembert, 2017), were used in the initial part of the project in 2019 to understand the most pressing needs of two of MICADO's user groups: migrants and representatives of non-governmental organisations. Reflecting on the possible power imbalance between researchers and research participants, it was deemed important to employ specific measures to raise awareness of the positionality and counterbalance it. More specifically, all researchers involved in conducting co-creative workshops participated in anti-discrimination training, and the MICADO workshops were designed to mitigate the effects of differing levels of privilege and power. Since the secondary analysis of this chapter compares the results of the SLR with those of the co-analysis phase, the following part focuses only on MICADO co-analysis workshops.

During the co-analysis phase, over a period of approximately half a year, the project consortium's local groups of Antwerp, Bologna, Hamburg and Madrid organised four to five workshops each, with six to 14 participants from the specific target groups of migrants and NGO representatives. The co-analysis in Hamburg took place in a series of five workshops. The first workshop was targeted at members of NGOs and other organisations from civil society working in the field of migration and integration. It was conducted on the premises of the CityScienceLab, where this research chapter has been authored. This workshop

had 14 participants, elaborating on their experiences as members of organisations accompanying migrant arrival procedures or with migration experiences themselves. The four succeeding workshops were each targeted at other groups of migrants according to categories that had been identified beforehand: refugees and asylum seekers, female migrants only, migrants who had lived longer than five years in the arrival country and a mixed group of migrants from various destinations. This separation was done to facilitate group discussion, provide a safe space for all participants and distribute participation between groups according to what were assumed to be different migration experiences to allow for broader knowledge. The invitation to these workshops was extended through NGOs that were already involved in the research project and which distributed the call across their wider networks. The workshops were held in the afternoon and evenings to allow people with work and care responsibilities to participate, and they were conducted on the premises of NGOs in order to create a more trustful environment for the migrant participants. Of the 21 participants, 10 were male and 11 were female, aged between 21 and 53 years and coming from different geographic, cultural and educational backgrounds (Diaz-Chorne et al., 2019).

Each workshop consisted of three elements: a warm-up exercise, a board game that asked participants for their experiences and what they had learnt during their migration story in a structured yet open way, and a journey mapping exercise that guided participants to sort their previous answers into structured processes. These workshops lasted three to four hours each and were documented by researchers using structured documentation sheets, which were used as the source for the following data analysis.

Secondary data analysis and comparison

This chapter compares the generated data and outcomes of the MICADO research through secondary analysis. Therefore, this section introduces the secondary and comparative analysis approach used.

Secondary analyses follow the approach of investigating a new research question with the help of extant quantitative and qualitative datasets from previously conducted studies (cf. Heaton, 2008). Older studies may also be re-analysed through a secondary analysis (cf. Heaton, 2008). While this practice is common in quantitative research designs since the 1950s, qualitative studies have, to a large extent, only made use of secondary analyses in the last two decades. This can largely be explained by the fact that it is considerably more difficult to preserve *and* make accessible the comprehensive contexts and datasets of qualitative

studies, while also keeping in mind data protection and other ethical questions. Secondary analyses should not be understood as a separate, individual method but rather as defining a way of accessing data and choosing the empirical material. In this form of analysis, data collection gets disconnected from the data analysis since previously collected material from another study is used (cf. Medjedović, 2014). The datasets may originate from a prior internal study or foreign data sources.

This chapter compares two datasets according to their meaningfulness for answering a complex research question in the field of urban migration. In order to reach insightful findings, the research follows the approach of comparative analysis described by Morlino (2018). First, clear types of objects to be compared (comparable units or sets) must be identified. Properties, meaning a set of characteristics or aspects of the set that are relevant for the research, must then be singled out (Morlino, 2018, pp. 37–38). After comparing the properties of these sets, a comparative analysis can be used to present the findings in a detailed narrative, as this is "the simplest and relatively most straightforward (strategy)" (Morlino, 2018, p. 91). In order to generate meaningful results, the more analytical strategy of process tracing can be applied to research with a limited number of cases. The difference from mere narrative explanations of the research "lies in the fact that process tracing requires a conversion from historic narrative into analytical articulation that produces an explanation based on theoretical variables clearly identified in the research design" (Morlino, 2018, p. 91). The following classification aims to identify these variables, which guide the process tracing for the comparative analysis.

In the secondary analysis, this chapter compares the two bodies of data generated in the aforementioned MICADO project during the two research phases: the data resulting from the SLR and that resulting from the co-creative approach. In order for the methodologies to be comparable, it is important to note that they both examined specific challenges for integration within specific domains. The results were clustered according to the five thematic fields and coded based on the challenges and characteristics of the results. In order to analyse the outcomes, we identified two sets to be compared: **systematic literature review data (Set 1)** and **co-creation data (Set 2)**. Within these sets, we identified the following aspects for comparison: **research field (Aspect A)**, **scope (Aspect B)**, and **specificity versus generality (Aspect C)**. By coding the two datasets according to these aspects we were able to conduct the comparison.

More specifically, for Set A we used the literature managing software Citavi and coded all 70 papers using the tag word function. For Set B, we used five documentation manuscripts that were produced after each workshop to summarise and order the output of the workshop. These were coded manually. The codes represent the abovementioned aspects: research field (size of dataset, sociodemographic structure of participant group), scope (local/regional, national, international) and specificity versus generality (challenge description, individual/general focus). Having analysed these codes, we were able to make statements about the level of detail in which the topics are covered and the regional scope of a study to help us understand the specificity and generality of the research results.

The comparison could thus be systematised. We analysed the individual aspects and compared the different aspects of both sets (i.e., 1A with 2A, 1B with 2B and 1C with 2C). Comparing the properties of the research sets would enable us to answer the research question introduced in the first section.

Analysis

In order to compare datasets A and B, the source data was coded according to the three previously named aspects: research field (Aspect A), scope (Aspect B) and specificity versus generality (Aspect C).

Firstly, 70 articles were assessed during the SLR, all dealing with challenges in relation to the five domains of housing, health, labour, education, and participation/transversal issues, comprising topics that influence all domains, such as language. In addition, 44 challenges within those domains were raised by 38 participants in total (from different groups of migrants as well as NGO representatives) in the five co-analysis workshops.

Aspect A: research field

This first code revealed the thematic fields addressed by the articles in the SLR (Set A) and the challenges raised during the co-analysis workshops (Set B). In the SLR review conducted in the MICADO project, the authors found more research on the topics of education, labour and participation and fewer results for the fields of housing and health in the context of migrant integration in Hamburg (see Figure 2). This discrepancy across the thematic fields in terms of

interest and work holds true for the other pilot cities as well (Diaz-Chorne et al., 2019).

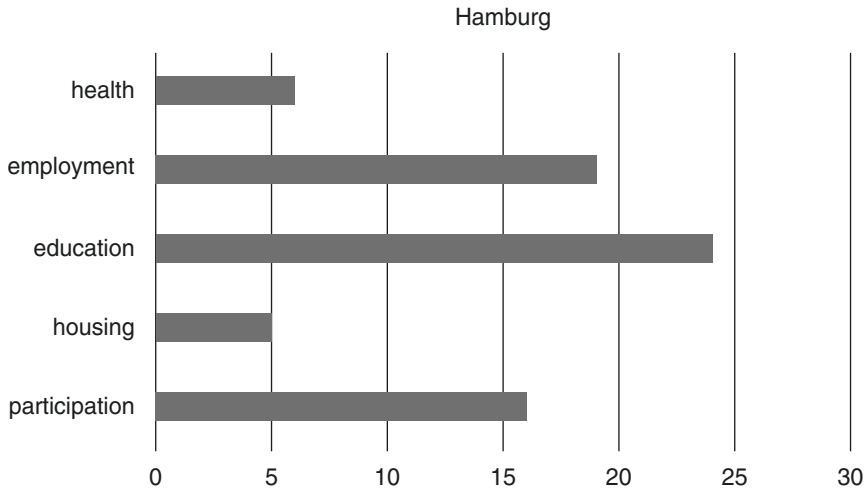

Figure 2. Topic distribution within the literature in the Hamburg research in absolute numbers (adapted from Diaz-Chorne et al., 2019).

During the co-analysis workshops, both migrants and representatives of crucial NGOs active in the field of migrant integration could raise what they felt to be the most pressing issues, questions and challenges in the same domains. Here, the share and frequency of topics raised differ from the result of the SLR and are more equally spread. While half of all challenges raised by individuals during the workshops were connected to the topics of education (25%) as well as participation or a transversal issue (25%), the remaining 50% were shared between the topics of health, housing and labour (see Figure 3).

Furthermore, in the co-analysis workshops, questions were raised regarding challenges in the domains, and most participants described issues and experiences on an individual level. This shows that while an SLR can be helpful to detect a certain dominance as well as gaps in a specific research field, a co-creation practice with the target group helps to gain information on distinct and individual experiences.

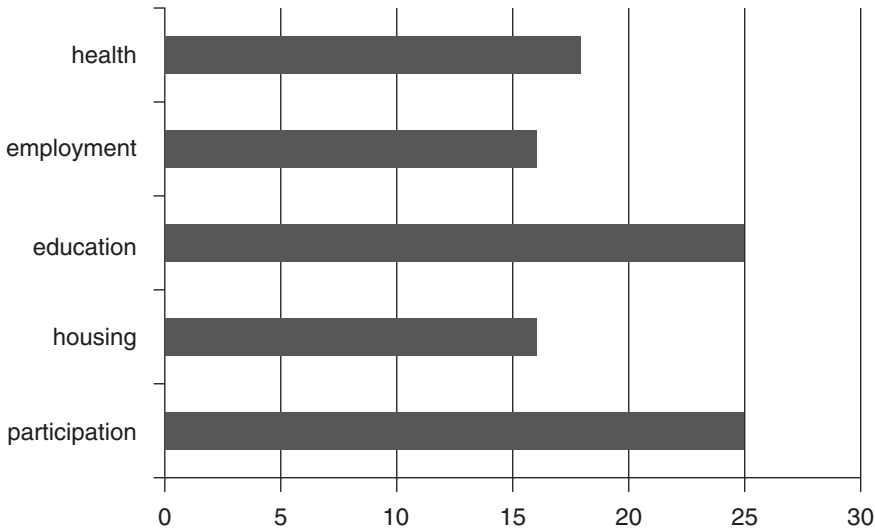

Figure 3. Distribution of raised challenges per domain during the co-analysis workshops in Hamburg in percent (own diagram).

Aspect B: scope

Coding all the articles reviewed in the SLR as well as all the challenges raised and discussed during the co-analysis practices also gives an insight into the scope of each dataset. This chapter distinguishes between the local or regional, national, and international scope of the results. While the majority of articles in the SLR (more than 87%) display results at a national or international level, most of the conversations held during the co-analysis workshops (73%) had a rather local or regional scope. This can be explained by the proximity of a migrant's experience to local infrastructures. Two examples help to demonstrate this. In the SLR, a study focused on the positive effects of anti-discrimination provisions to decrease wage discrimination against migrants (Bernhard & Bernhard, 2016). In the co-analysis workshops held in August 2019 in Hamburg, migrants expressed their experiences of discriminatory behaviour during job interviews. The following quotes are taken from the audio recordings of these workshops and are presented anonymously in order to protect the migrants' privacy. "Many companies said, 'If you wear a headscarf, it's a no'", said a Syrian programmer. Another referred to her interview for an internship at a nursing home: "The boss said, you cannot work here when you wear a niqab". In connection to housing, another SLR paper discussed the relationship between residential segregation and neighbourhood satisfaction (Dill et al., 2015), while migrants in the co-analysis workshops talked

about their housing experiences: "We don't have contact to our neighbours", one research participant said regretfully. "Private house owners don't want to rent out to Arabic tenants", said another. One research participant reported incidents of insecurity in the shared hallway of their home: "I find my letters opened in the mailbox. Somebody is opening and reading them".

Aspect C: specificity versus generality

This chapter also analysed the main focus of the articles (in the SLR) and the challenges for integration (addressed during the co-analysis workshops), asking whether the key issue and results allowed insights into individual issues or for a larger group. The comparative secondary analysis showed that 80% of the articles reviewed in the SLR had a general focus. If qualitative or quantitative studies were conducted with a group of participants, only the summarised results were presented in the papers in order to offer general propositions. Many of the articles discussed nation- or state-wide policies that formally structure the arrival and integration process and are, therefore, essential for researchers to know about—thus, giving insights into the *conceptual urban* of policies and regulations.

During the co-analysis workshops, individuals were asked to share their experiences of arriving in a new city with the rest of the group. The focus of 36% of all challenges raised during the workshops was on rather individual issues or strategies. In another third of all the challenges raised by the participants, the discussion moved from an initial individual perspective to a more general one when other participants could relate to it or because the group collaboratively raised the conversation to a broader level. An example is the multitude of informal information points that migrants would frequent within their communities in order to receive necessary information about opaque, formalised processes. In these conversations, it was possible to learn about individual, sometimes informal, nuanced narratives that are highly relevant if one seeks to understand the complex structures of facilitators and hindrances of integration processes.

Conclusion

Answering our research question on the benefits of a combination of SLR and co-analysis, we argue that quantitative studies and policy analyses give insights into wider discourses within migration and integration research, while co-creation practices and the participation of migrants and those supporting

their arrival procedures give researchers valuable insights into the reasons why policies and integration measures might fail to match their objectives and what compensational practices migrant communities establish in order to overcome hindrances in formal arrival processes. More specifically, this chapter has made statements on the scope and characteristics of the data in the SLR and its meaningfulness for positions and knowledge gaps in the area of research area as well as the impact of policies on a national and international level. This was compared to the insights generated by analysing the co-analysis data, its representation of distinct, fragmented experiences and individual daily practices, and its usefulness for enlightening local/regional integration procedures.

This chapter points out the benefits of combining both research approaches in order to understand complex research areas within migration research and understand intersected layers of arrival processes.

The analysis of research fields (Aspect A) has shown that an SLR facilitates an overview of the available knowledge and, therefore, helps to detect thematic dominance and gaps. In this case, the analysis of the body of papers showed that while employment and education are well-researched areas within migration research, health and housing remain understudied. The combination with co-creative practices can help to cross-check the situation. Do the needs voiced during the workshops mirror the distribution of effort and interest in the literature? If comparable questions are asked during co-creation workshops and if the distribution of interests differs across thematic fields, this can prompt us to steer future research in new directions. By analysing the co-analysis data, we found a perceivable demand for support in the fields of housing and healthcare. While this already sheds light on gaps in migration research, it also suggests the need for more research in these fields.

A closer look at the different foci of the content of the SLR and the co-analysis reinforces the argument that a combination of the two methods leads to more comprehensive and, therefore, meaningful insights as the combination provides knowledge on formal frameworks and policy levels, while at the same time shedding light on individual, often informal patterns that facilitate or hinder the arrival process. This can be exemplified by the thematic focus of each research paper and challenge mentioned. The examples of wage discrimination and residential segregation discussed above show that while an SLR gives an overview of formalised systems and policies, only co-analytic research with migrants offers explanations as to how or why policies at times do not have a positive influence on integration procedures. This shows that research can benefit from both

perspectives: A general view on policy influence on large populations of people can help us understand broad structures and developments. However, looking at the individual level helps us understand the multi-layered hindrances and obstacles that might prevent a policy from being fully effective. While the SLR assessed knowledge of formalised systems, shedding light on major migration policies, systemic border regimes and identity politics within these five thematic fields, the co-analysis workshops with migrants and representatives of NGOs surveyed everyday practices and tacit knowledge connected to overcoming challenges in the same five domains. These everyday practices entail strategies for orientating oneself within complex administrative systems and obtaining information on necessary steps and supporting institutions.

Our research has shown that those research methodologies that focus on a quantitative analysis of migration (such as, but not exclusively, systematic literature reviews) are able to shed light on the managerial perspective of migration and integration (the *conceptual city*). SLRs allow statements with a broad scope, making visible quantitative characteristics and analysing policy impacts, as well as obtaining results on research area dominance and gaps, methodologies and instruments. SLRs enable insights at a national and international level and focus on policy impacts. At the same time, research that lets actors and city-dwellers participate enlightens the open-ended, ever-changing and performative *factual city*. Methods such as co-analysis make visible individual daily practices and tacit knowledge, thus shedding light on multi-perspective, transdisciplinary and human-centric research areas. This is especially important in migration research, as migrants often have limited access to dominant knowledge repositories due to the interweaving of language, educational and cultural barriers, difficulties in connecting to the labour and housing markets, discrimination and other previously identified hindrances. These difficulties can be represented through distinct, fragmented experiences on a more local and individual level. Expanding the narrow researchers' perspective by involving migrants in participatory research such as co-creation brings their tacit knowledge repositories into focus.

This argument has been made on the basis of a comparative data analysis of two distinct research methodologies. Future research could address a meaningful intersection of distinct bodies of data and formulate a methodological approach in order to establish an integrated research practice for complex migration topics.

Notes

1 "Eine metaphorische oder herumwandernde Stadt dringt somit in den klaren Text der geplanten und leicht lesbaren Stadt ein", translated by the authors.

2 https://www.micadoproject.eu/

3 All partner countries represent a Western European perspective; the project results thus shed light only on Western cultural and political regimes. It might be interesting to conduct further research on co-creative methodologies with migrants in other contexts; e.g., Scandinavia or Central Eastern Europe.

4 There is no consistent use of terminology in the literature on co-creation (Apers et al., 2019). The authors of this chapter follow Sanders (2013) and use the terms "co-design" and "co-creative practices" as an umbrella term to describe the general concept. At the same time, they follow Stembert (2017) in the division of four sub-categories to describe the complete co-design circle, namely "co-analysis" (exploration of context and its possibilities, definition of use cases), "co-design" (definition of the main functionalities of generated solutions), "co-evaluation" (evaluation process) and "co-implementation" (definition of the implementation process and influencing factors for the adaptation or rejection of the solution).

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Co-creative Twinning: Participatory Practices and the Emergence of Ownership in Digital Urban Twins

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Abstract. This paper presents a unique case study of co-creative modelling in a digital urban twin, exploring the inclusion of diverse concerns, stakeholders, and practices in the building of a complex socio-technical system. It does so by employing a co-creative methodology for modelling complex socio-ecological processes in the Connected Urban Twins Project (CUT) Hamburg. The methodology involves early engagement of stakeholders during problem formation and collaboration through a series of co-creation workshops. Through the examination of this collaborative effort, this research aims to describe the relevant factors and practices associated with co-creative twinning, particularly in the context of engaging diverse stakeholders in building socio-technical systems. By analysing this process, valuable insights and lessons will be derived for twinning experts seeking to involve citizens and other stakeholders in their twinning projects. Furthermore, this research critically reflects on the emerging interactions and outcomes of the twinning process, discussing the feasibility of the methodology in terms of enhancing transparency, building trust, reconfiguring knowledge and stakeholders in digital urban twins, as well as supporting collective decision-making and ownership. In order to support twinning experts in co-creative efforts, the research derives lessons learned suitable for involving diverse stakeholders in co-creative twinning efforts.

Keywords: Digital Urban Twins, Co-creation, Participatory Modelling, Participatory Digital Urbanism, Sustainability

1 Introduction

In recent years, digital urban twins (DUT) have become crucial components of digital cities. While a formal definition of DUT is still lacking, it is generally acknowledged that a digital twin is understood as a virtual representation of a physical entity, driven by data and utilised for prediction, monitoring, control, and optimisation (Clemen *et al.*, 2021, pp.

45). This can have the form of, but is not limited to, 3D-model of cities, VR applications in planning, or urban data platforms. Batty (2018, p. 1) suggests that any such system resembling the operation of another is a model. And models are abstractions – a representation of the system that does not aim to replicate the original in the same level of detail. This process of representation thus is a practice of constructing a twin through the inclusion of some data and exclusion of other.

However, existing definitions overlook the knowledge and data included in the twin and the stakeholders involved in its construction. Solman *et al.* (2022) argue that some concerns, especially those related to social aspects, are often excluded from twins due to their complexity. Batty (2018) further supports this notion, stating that these models rarely incorporate the social and economic functions that shape a city. Consequently, defining a twin as an object fails to recognise *twinning* as an active process involving decisions and actions regarding its design, and the inclusion and exclusion of perspectives, knowledge and data.

To enable broader stakeholder participation and diverse practices, Solman *et al.* (2022) propose examining twinning processes from a co-creative standpoint, emphasising engagement and deliberation. Similar arguments are echoed in the model development community, advocating for multi-stakeholder modelling approaches to incorporate diverse perspectives in socio-technical systems (van Bruggen at al., 2019; Tolk *et al.*, 2022). Despite increasing calls for co-principles in modeling, empirical case studies and best practices in Digital Urbanism remain limited.

This research focuses on the co-creative twinning of complex social functions within a DUT using a participatory modelling approach. Specifically, the paper explores ongoing research in Hamburg's evolving modular digital urban twin infrastructure. It builds upon established participatory modelling frameworks in resource management and applies them to the development process of the Connected Urban Twin project. The case study involves representatives from public administration, civil society, and the private sector, who actively participate in co-creation workshops. The goal is to design a model addressing climate protection and social equity, specifically gentrification processes in Hamburg triggered by climate protection measures.

To guide this investigation, the following research questions are addressed:

Q1: How can complex socio-ecological topics be effectively modelled in a Digital Urban Twin through the active involvement of a diverse set of stakeholders?

Q2: Which new practices emerge from co-creative twinning, and how does this facilitate the emergence of agency, trust and ownership?

The paper is structured as follows: It begins by introducing the case study and clarifying key concepts. Next, the workshop methodology and co-creation process are presented.

The results section analyses the emerging twinning practices and challenges encountered during the co-creative modelling process, based on recently concluded workshops. The discussion section reflects on the research goals and presents preliminary conclusions.

2 Literature and Methods

2.1 Case Study

Prior to selecting the case study, the researchers had to define an umbrella topic leading the experiment. We select two seemingly opposing public values for the umbrella topic: climate protection and social cohesion. In bringing these topics together, we made it possible to expose safely the tension between their circumstances and discover hidden but valuable strategies in addressing and planning for both values.

Given its existing digital infrastructure, open data laws, and ongoing digitisation initiatives, Hamburg was selected as the case study for this research. It ranks highest among German smart cities, as indicated by a 2021 index (Statista, 2023a). With its population size of 1.89 million (Statista, 2023b) and commitment to achieving carbon neutrality by 2045 (Hamburger Senat, 2022, p. 16), Hamburg provides an ideal context for investigation. Additionally, the city has implemented policies like the social preservation ordinance (Soziale Erhaltungsverordnung) to safeguard residents from displacement in their neighbourhoods.

The CityScienceLab in Hamburg serves as a living laboratory[52], collaborating with the city's public administration to develop and test digital urban technologies. One notable research project conducted by the CityScienceLab is the Connected Urban Twins project (CUT), which has received substantial federal funding of 21 million Euros and stands as one of Germany's largest smart city initiatives. In the CUT, the cities of Hamburg, Leipzig, and Munich are working together to establish a modular digital infrastructure that enables the creation of what-if scenarios to enhance governance processes (Schubbe, 2023). As part of this endeavour, a series of real-world experiments are being conducted to test technologies with a diverse range of stakeholders.

This research is situated within one of these real-world experiments, comprising a four-month experimentation phase in the first half of 2023, preceded by a preparatory phase

[52] Living laboratories, here, are understood as an emerging instrument in innovation policy that tests new sociotechnical arrangements in situ and at a meso-scale, reconfiguring societies (Engels *et al*., 2019). These test settings are characterized in their reciprocity with the environment which they modify (Marres and Stark, 2020).

of approximately three months. Noteworthy collaborators for this research include the project partners involved in the CUT (see acknowledgements).

2.2 Literature

Science and Technology Studies provide analytical resources to understand how technologies can be co-created and with what effects. A great deal of Participatory Design and Computer Supported Cooperative Work research is directed at designing computer-based systems, with interdisciplinary teams following rapid prototyping approaches. The field emerged first in private sector work environments as a reaction to the disruptive force of technological innovations, and aimed at strengthening workers' control over their work processes (Zimmerman and Forlizzi, 2014; Kensing and Blomberg, 1998). Likewise, user-centered design practices and Design Thinking emerged in Human-Computer Interaction, focusing on iterative design and development processes that put users and their needs at the center in order to ensure usability and uptake of products (Ghaoui, 2006; Stembert, 2017). While these practices have oftentimes focused on building prototypes, seldomly going beyond the early analysis and design activities, others have actively involved users throughout the entire development phase with the goal of developing general, tailorable software products. Such are the Cooperative Experimental System Design (CESD) school (Grønbæk *et al*., 1997 & 2002) and the Participatory Modelling (PM) Community (Abrami *et al*., 2021). The latter involves non-scientist stakeholders early in the modelling process, during the preparation and organisation stages, all the way to the follow-up stages such as dissemination and evaluation.

While CESD and PM approaches have been well established and documented in Human-Computer Interaction and Socio-Ecological Settings, case studies engaging these approaches in digital urbanism remain sparse. Despite an increasing amount of literature calling for a participatory approach to the Digital City, participatory digital urbanism is still oftentimes limited to the design analysis phase pre-development, or a co-creative delivery of services and products post-development, and is oftentimes facing the challenge of difficult integration into procedures of local governments (Harvey *et al*., 2022).

By disregarding the construction of urban technologies, participatory digital urbanism misses the opportunity to engage with the wider implications of participatory processes within socio-technical systems, failing to meaningfully address its performativity and constructedness, and to transform scientific, democratic and political orders (Latour, 2007; Chilvers and Kearnes, 2020; Felt *et al*., 2017).

It is this the goal for my research, engaging in the co-development of urban technologies with a diverse set of stakeholders through a relational perspective, reflecting on the constructed, emergent, and interconnected realities of digital participatory urbanism. We look at participation not just as a starting point for, or an outcome of, the development of urban technologies, but as the very means to build these. Thus, this research expands on Solman *et al*.'s (2022) call for scientists to engage in the co-creation of digital twins, learning about the practices of engagement and deliberation that digital twins can foster.

2.3 Methodology

By adopting the perspective of Solman *et al*. (2022), which emphasises the inclusion of diverse stakeholders in the early stages of the development process, this research places co-creation at the centre of digital urban transformation. Co-creation offers several advantages, such as accessing various levels of knowledge and uncovering latent and implicit needs and desires of participants (Thoneick *et al.*, 2021). It also facilitates collaboration between groups that typically wouldn't work together, fostering a shared understanding, safe spaces for sharing, and empowerment of minority perspectives (Sanders and Stappers, 2008).

Co-creation can be defined as a collaborative process involving the active participation of multiple stakeholders in the creation, design, and development of new ideas, services, or products (Van Praag, 2021). It recognises the significance of engaging city residents, policymakers, urban planners, technology developers, and other relevant actors to collectively shape and contribute to the design, implementation, and utilisation of digital twins. In recent years, these concepts have evolved toward more user-centric and co-creative approaches, particularly in technology development, where users are regarded as experts of their experiences. During co-creation, collaborators jointly define the problem and create the solution, uncovering latent knowledge that informs system architecture requirements (Stembert, 2017).

While the benefits of citizen involvement in smart city initiatives are widely acknowledged, disagreements remain about what constitutes „good" engagement (Felt *et al*., 2017), and the absence of a solid conceptualisation of participation, co-production, and co-creation can result in superficial forms of engagement that fail to empower citizens, capture diverse perspectives and knowledge, and redistribute decision-making power. Our definition draws on several approaches in the field, delineating four essential conditions for a reflexive and transformative practice that we call co-creative twinning.

A first essential condition are the **twinners** involved: Co-creative twinning entails collaboration between the designers and implementers of digital urban twins and the beneficiaries of these models. It involves citizens contributing their input to create the

product (Ostrom, 1996; Boyle and Harris, 2009; Meijer, 2012). In the context of our co-creative twinning research, we involve various stakeholders in the creation and evolution of digital models of urban environments. We engaged with planning authorities, critical urban activists, civil society actors from the fields of climate urbanism and rental justice, representatives of proprietor's and tenants' organisations.

The second essential condition are the **practices** of co-creative twinning. Building on work in public administration research, we see co-creative twinning as an enhanced form of participation (Bovaird, 2007) in which citizens actively engage in the design, implementation, and evaluation of the Digital Urban Twin. Co-creation emphasises the collaborative efforts among diverse actors, including researchers, practitioners, users, and other relevant parties. This research made an active attempt to move beyond deliberative practices, actively co-creating the digital city model by engaging with concepts of the socio-technical system, engaging with digital tools, reading code snippets, and building the models literally with their own hands on a screen.

A third condition is the emergence of **agency** in the twinners by enabling twinners to actively contribute to the design and implementation of public initiatives. The notion of agency is closely tied to power – spatial agency implies that it is possible to engage transformatively with structure, being able to intervene in the world with the effect of influencing a specific process or state of affairs (Awan, Schneider and Till, 2011). In our research, we examined agency as a way to share decisional power on the aspects included in the modelling process and shape the process according to participants' needs and wishes.

A fourth condition of co-creative twinning is the **reflexivity** of the process. Coproductionist STS perspectives have started to consider participation as objects of study and intervention of their own right, seeing participation as a constitutive of science and democracy rather than outside of it (Latour 1993; Chilvers and Kearnes, 2020). Committing to reflexive experimentation means ongoing responsiveness to emergence, openness about the uncertainties of participation, and attending to exclusions and inequalities within wider ecologies and systems of participation (Chilvers and Kearnes, 2020).

Our research in co-creative twinning, then, includes (1) examining the twinners involved, their needs and interests and the means of engaging a diverse set of stakeholders, (2) detecting emerging twinning practices and the reconfiguration of knowledge, (3) investigating agency and the sharing of decisional power, and (4) analyzing the process in regards to openness and reflexivity. By adopting this framework, the analysis provides a comprehensive understanding of co-creative twinning and its underlying elements.

2.4 Research Design

Following the above mentioned conceptualisation of co-creative twinning, the research expands on existing participatory modelling frameworks established in resource management, and designs and applies a custom-made methodological framework to the twinning process. The experimentation phase took place from February through May 2023 and consisted of four consecutive workshops. The first happened online via a video conferencing tool, aided by an online whiteboard tool for note taking. The other three workshops took place offline, in the location of the CityScienceLab in Hafencity Hamburg, using a Digital Multi Touch Table (Fig. 1). The research laboratory has a large experience space where workshops can be held, and its character as a non-governmental research institute helped to create a somewhat neutral space for participants from governance and activism. In the following, two intersected research strands are described. The first is the co-creative modelling methodology aiming at a collaborative twinning process, which is in both parts research methodology and case study description; the second is the methodology for data collection and analysis.

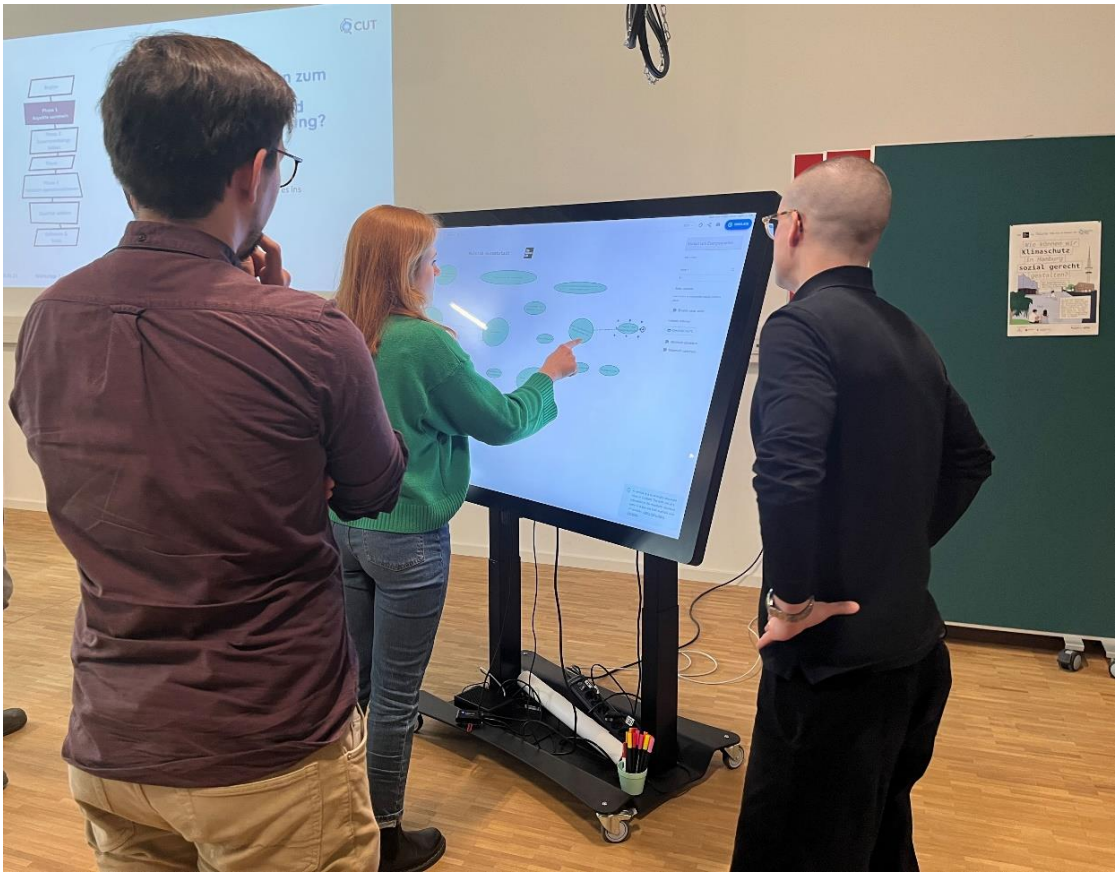

Figure 1: Workshop situation: Participants mapped aspects in an online tool using a Multi Touch Table.

2.4.1 The Co-creative Modelling Process

The goal formulation for the experiment phase was to design, implement and test a co-creative modelling workshop methodology that would invite diverse stakeholders to the process. In parallel, technological development was taking place and was informed by decisions made in the modelling workshops. These two iterative processes intertwined and iteratively conjoined along the timeline (Fig. 2), however, this research shall focus on the co-creation process. More information on the development process can be found in (Herzog, 2023).

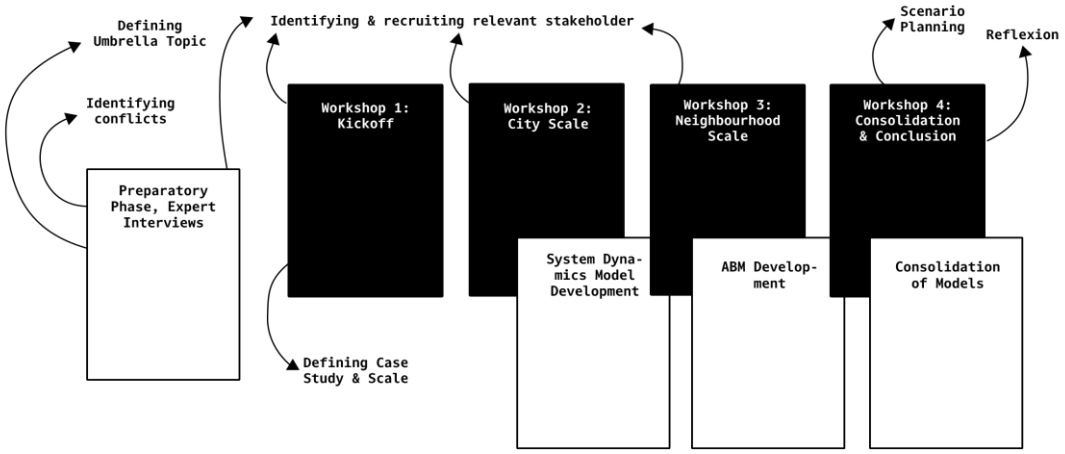

Figure 2: The experimentation process oscillated between planning and development phases conducted by the researchers (white), and workshop phases with stakeholders (black).

The twofold research process called for a flexible approach that would adapt in course of action based on participants' decisions and expressed needs, wishes and concerns. Cornerstones of the co-creation process were four workshops (Fig. 2), of which each had ramifications for the following workshop. The decision on an umbrella topic had consequences for the city-scale, the city-scale had an impact on the model type, the model type influenced the co-creative methodology. By not predefining topic, scale, model type, and methodology, we created an open-ended process that allowed for participants to have influence on the problem framing, the methods and the twinning procedure.

Voinov and Bousquet's (2010, 1273) stages of participatory mapping[53] helped frame activities, as they define elements of the modelling process that can be rearranged in

[53] The stages of a participatory modelling process are: identify project goals, identify and invite stakeholders, choose modelling tools, collect and process data, discuss system & build conceptual model, run model & discuss results, discuss and define scenarios, analyze model & discuss improvements, present results to other stakeholders and decision makers. These stages include loops back and forth, can

order. In our participatory modelling process, these stages were conjoined into (1) a preparatory phase to define the umbrella problem in a student workshop by building Wicked Questions[54] merging two opposing topics together, resulting in the topic of climate protection and social equity, and identify conflicts within that umbrella topic through informal expert interviews, (2) the Kickoff workshop, where a specific case study was selected within the larger umbrella topic of climate protection and social equity, and decisions were made on the scale the simulation models should represent and the questions they should address, (3-6) the development phase of two models of Hamburg that cover the aspects and their relations identified by the stakeholders, (7) simulation of various scenarios with policy levers and reflecting together with the research team on the simulation results and the feasibility of such systems in order to support their practice, and (8) consolidating both models and integrating them in the wider context of the Digital Urban Twin. Identifying relevant stakeholders involved in that realm and recruitment through a snow-ball system was an ongoing activity throughout the process.

The stakeholder selection is a crucial factor in co-creative processes as it significantly influences the outcome of the designed model, product, or service. In our study, stakeholder acquisition was an ongoing process. It involved desk research, personal recommendations, and existing networks. Expert interviews were conducted to gain insights into climate protection and social equity, followed by a mapping of relevant stakeholders. The umbrella topic of climate protection and social justice was defined early in the process. For stakeholder selection, we defined **areas of expertise**: for the *administrative and legal* view we selected the local government ministries for planning, housing, nature and climate protection and members of the district advisory board, for the *planners'* view we selected district planning offices and private planning companies, for the *aggregated perspectives of tenants', climate protection and social justice* we selected non-governmental organizations in the realms of coding and fab labs, environmental and climate protection, tenant counseling and housing associations, and for a representation of *directly afflicted perspectives*, we selected tenants and property owner associations as well as neighbourhood initiatives. Representatives of these areas of expertise were then identified either through desk research or personal networks, and subsequently contacted via email or telephone. The aim was to have at least one representative from each area of expertise present in each workshop, however this goal could not always be achieved. Some participants represented several perspectives (a lawyer in tenant counselling can at the same time be a person directly afflicted by push-

be reordered, and don't necessarily all have to be met within one participatory modeling process. (Voinov and Bousquet 2010)

[54] Wicked Questions are a method of a collection of group processes and methods named *Liberating Structures*. Groups can use Liberating Structures to facilitate innovative collaboration and radically change interaction. More information on https://www.liberatingstructures.com/

out dynamics in their neighbourhood), however they were counted in their primary role (Fig. 3). Stakeholders were also identified through professional and personal networks of project partners and researchers. A snowball system was employed, with participants who agreed to participate suggesting other relevant stakeholders.

	Participants	Areas of Expertise
Workshop 1	9	admin & legal: housing (2), planner (3), tenant counsellors (2), urban justice activists (2)
Workshop 2	3	admin & legal housing (2), tenant counsellors (1)
Workshop 3	6	admin & legal housing (2), tenant counsellors (2), direct tenant (1), direct landlord (1)
Workshop 4	5	admin & legal housing (3), tenant counsellors (2)

Figure 3: Participation varied between the workshops with highest attendance by members of the housing administration and tenant counsellors. Climate protection representatives had been invited but were unable to attend any of the workshops.

The **first workshop** was framed as a 2-hour online kickoff workshop. It aimed at bringing together the working group and presenting the umbrella topic of climate protection and social equity. It let participants formulate and vote on the question under the umbrella topic, deciding on the scale of the model and setting the subsequent time frame according to their availability. This resulted in the question formulated: “How can we uncouple ecological modernisation and economic gentrification?”. Participants decided it would be beneficial to model this topic on two scales, the entire city scale and the neighbourhood scale (Fig. 4). This led the project team to the change the process and methodology supporting the building of two models: a system dynamics model[55] for the entire city and an agent-based model[56] for the neighbourhood scale.

[55] System Dynamics is an analysis tool that describes a system in terms of its structure and function that generate system behaviour. System Dynamics modelling is most useful for understanding the behaviour of trends over time. (Exter and Specht, 2003).

[56] Agent-based models are computational models that are able to express the dynamics of complex adaptive systems, including the behaviour and interactions of agents within the simulated time and space of a virtual environment. A distinct feature of ABMs is the capacity for linking micro-, meso-, and macro-level factors, shedding light on macro-phenomena emerging from micro-level behaviors and meso-level network interactions. (Shults and Wildman, 2020)

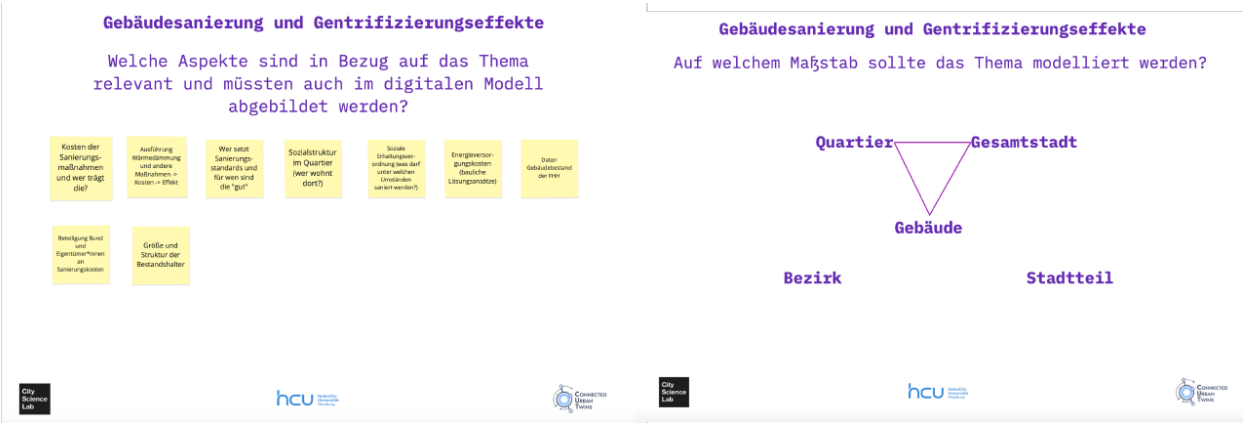

Figure 4: Screenshots from the first modelling exercise (in German). Left: Participants posted relevant aspects of the selected case study (Economic Gentrification vs Ecological Modernisation) on sticky notes. Right: Participants decided to examine the city-scale and the neighborhood-scale, and relate them to the building scale.

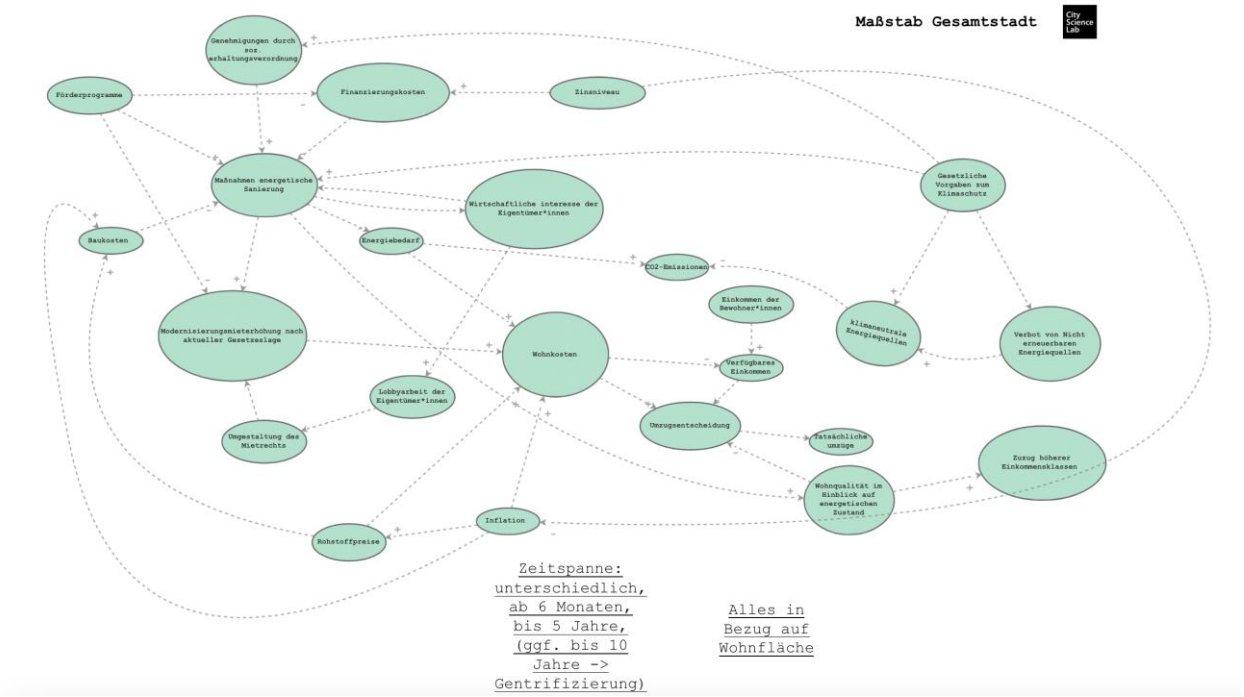

Figure 5: Screenshot from the second workshop (in German): A system dynamics model of the city scale, in which relevant aspects within the case study were mapped and put in relation to each other. For instance, economic modernisation was put in relation to funding programmes, financing costs and permission requirements. Gentrification was translated into the decision to relocate, which was put in relation to disposable income, and living costs.

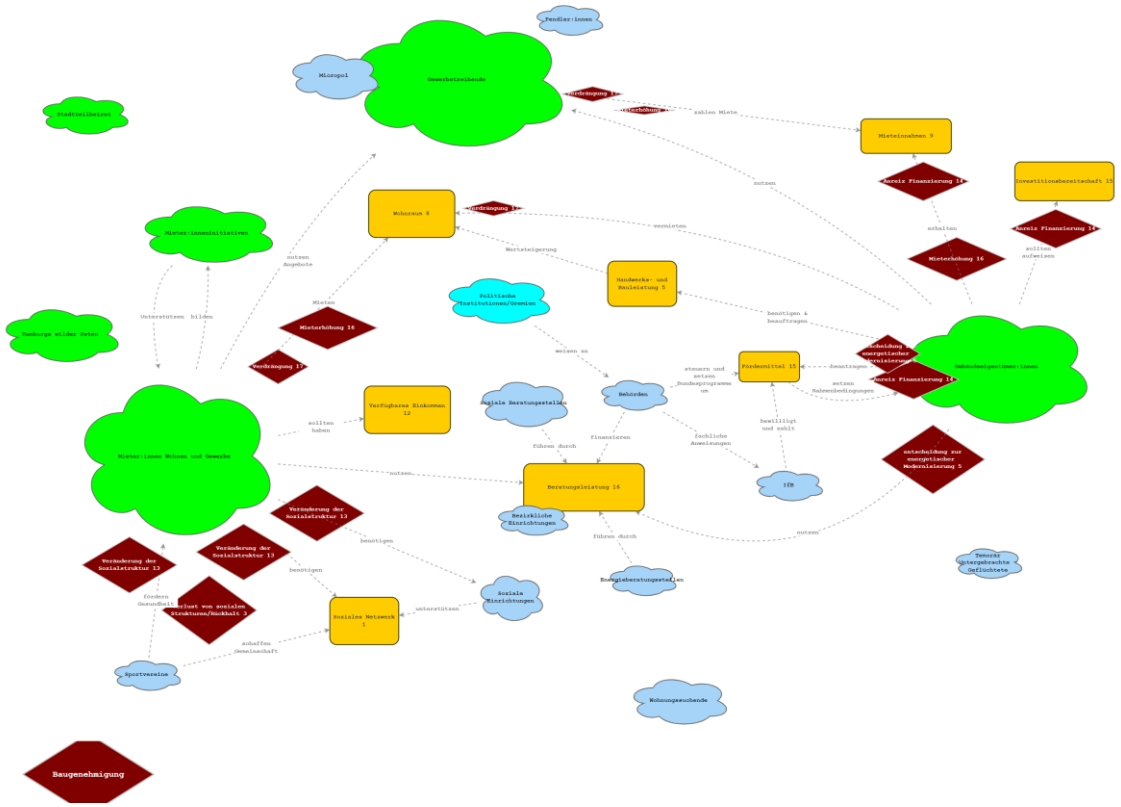

Figure 6: Screenshot from the third modelling workshop: A map was created showing the interaction of direct actors (large cloud) and indirect actors (small cloud), resources (rectangle), and dynamics (diamond). Participants identified tenants, proprietors, and local business owners as main actors. Main resources were the willingness to invest, counseling offers, funding, and disposable income. Main dynamics were push out, rent increase, financing incentives, change of social structure.

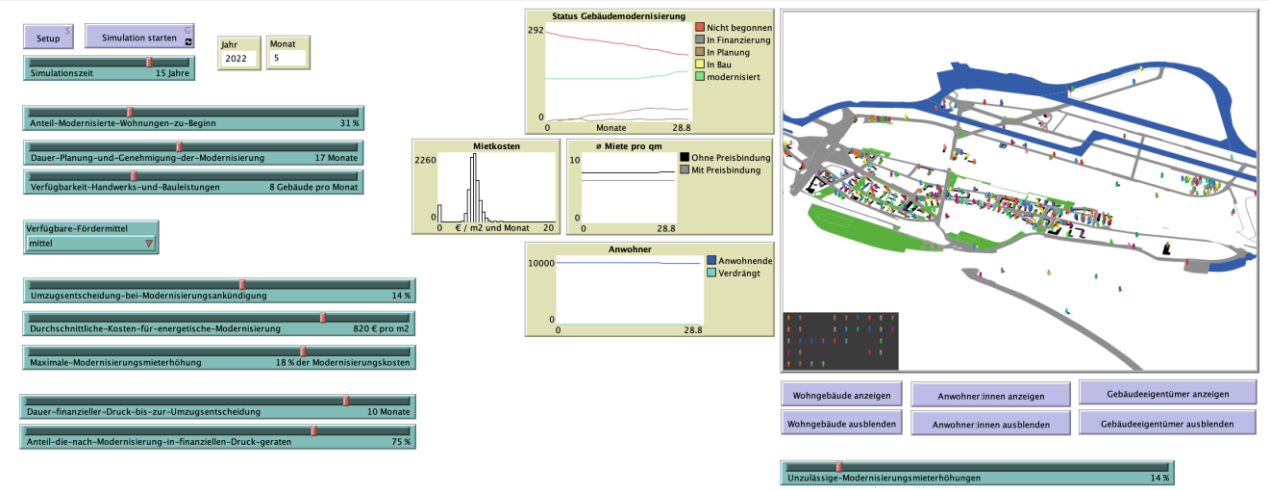

Figure 7: Screenshot from the resulting ABM model, showing interconnections of ecological modernisation and economic gentrification on a meso level for the selected neighbourhood. This model was used in the fourth workshop for testing scenarios.

The **second workshop** then aimed at building the system dynamics model, making use of existing group modelling frameworks (Voinov and Bousquet, 2010; Exter and Specht, 2003; Barreteau, 2003). The half-day workshop was facilitated by a project member of the CUT team, and ideas were mapped using a digital multi touch table and the web based modelling tool *Insight maker*[57]. Participants were asked to name all important aspects of the topics of ecological modernisation and economical gentrification, which included defining these concepts. In a second step, the aspects were put in relation to each other, the third step was operationalising them (Fig. 5). In a second phase, potential neighbourhoods were jointly selected with the stakeholders, based on development areas and areas in the social preservation ordinance.

The **third workshop** focused on the selected neighbourhood, aiming at jointly defining the relevant aspects for the agent-based model by applying an adapted ARDI methodology[58]. In this full-day workshop participants jointly discussed relevant actors, defined the resources those actors were managing, included drivers of change as dynamics in the field, and mapped the interactions (Fig. 6). After this workshop, the project team translated the workshop results into an ABM model using the tool Netlogo[59].

The workshop results were presented in the **fourth workshop**.[60] In this half-day session, the two models were discussed in terms of what concepts were missing from them. The participants were then invited to formulate scenarios that could be tested with the twin models (Fig. 7). In testing the scenarios, discussion arose over concepts and policies. In the final reflection, questions were answered regarding the applicability of the model in work and policy contexts.

[57] https://insightmaker.com/

[58] ARDI (Actors, Resources, Dynamics, and Interactions) is a co-construction method for participatory modelling, usually used in natural resources management. In participatory workshops, various stakeholders co-construct a "conceptual model" of the functioning of a context or territory, according to an overarching, negotiated development question. This sharing of representations is done by means of a series of workshops during which Actors, Resources, Dynamics, and Interactions constituting the profile of the territory are identified and clarified. (Etienne *et al*., 2011)

[59] https://ccl.northwestern.edu/netlogo/

[60] Both models have not yet been published, but the data can be downloaded.
The System Dynamics model data can be downloaded here: https://cloud.hcu-hamburg.de/nextcloud/s/YoP2zg3RsgMKyrf
The ABM model data can be downloaded here: https://cloud.hcu-hamburg.de/nextcloud/s/a5PfsxBXrEWJzCJ

2.4.2 Data Collection and Analysis

This research follows an explorative research design, oscillating between ethnographically-inspired field work and theory adoption (Brüsemeister, 2008). Data collection was conducted during the four above mentioned workshops, but extended over the whole preparation phase, starting around late summer in 2022. Data was gathered in team meetings, both online and offline, during informal interviews with participants, expert interviews, in workshop settings and in reflection conversations. The material was gathered using participatory observation, informal interviewing and document analysis, and consisted of observation notes, field diary notes, interview transcripts, meeting notes, photographs, audio recordings, emails and other artifacts of communications such as powerpoint presentations, as well as the workshop results documentation. The material was coded in MaxQDa using open codes (von Oertzen, 2006). Of these codes, clusters of relevant aspects were formed in relation to the research question and the four dimensions of co-creative twinning:

(1) Twinners: This includes codes on stakeholders involved in the co-creative twinning process, both internal and external to the CUT project. Analysis focused on the conditions for and access to participation. The codes included subgroups (1.1) Building Community, (1.2) Performing Expertise, (1.3) Finding and Making Time.

(2) Practices: This category includes codes showing the practices of collaboration that emerge when citizens actively engage in design activities. This category includes codes of the subgroups (2.1) Filling Gaps, (2.2) Making explicit, (2.3) Quantifying Uncountables.

(3) Agency: The third category encompasses findings on moments when twinners were able to engage transformatively with the structure or process, shaping the process according to their expression of needs and wishes and actively contributing to the design and implementation of the twin. This includes subgroups (3.1) Switching and Staying in Perspective, (3.2) Appropriating the process, (3.3) Co-owning the Product.

(4) In the fourth category, the focus is on moments that highlight the reflexivity of the process. This entails responsiveness to emergence, openness about uncertainties, and attending to exclusions and inequalities of the system of participation. The code subgroups here are (4.1) Transparency and Trust, (4.2) Designing for (Dis-)Order, (4.3) Open-Endedness.

The results will be presented in concise paragraphs referring to the data and related documents. An interpretation and discussion of the results will be provided in the subsequent chapter.

3 Data and Results

3.1 Twinners

3.1.1 Building (and Making Use of) Community

It is important to highlight the relevance of **existing personal networks**, as they played a major role in participant recruitment. Cold-call email acquisition had a lower success rate than recruiting participants through personal networks. One stakeholder's agreement to participate was based solely on a strong existing relationship with one of the researchers:

> I didn't know what I was doing here, but because I've known (…) for ages, I came. When he asks me to come, I come. (WS3/1, Pos. 333[61])

Existing relationships came into play during the workshops. Participants who knew each other previously used the time together to **catch up on work** amidst their busy calendars. During the online workshop, one participant wrote to another in the chat about a work-related topic, and addressed her during the introduction round:

„Please check the chat, if I can't reach you otherwise.“ (WS1/1, Pos. 19)

Some participants were co-workers who aimed to **coordinate their inputs** and reach agreements on topics before engaging with the group (WS2/1, Pos. 61-67 & 294; WS4/1, Pos. 66-67).

New relations were also formed during the process. Two participants working in the same field but previously unknown to each other developed familiarity and even **formed alliances** to advocate for their agendas (WS3/1, Pos. 315). Participants **socialised** during breaks and workshops, further strengthening community bonds. Practices of **storytelling** and **humour** were employed by participants and facilitators alike. Humour helped overcome frustration in difficult situations, and it also facilitated understanding across political disagreements. As participants were asked to map the process of rental increase in the third workshop, the representative of landowners and the counselors for tenant rights had opposing views which could have led to conflict bus was dissolved by humor (WS3/1, Pos. 322-327). Storytelling was employed to share knowledge on complex definitions. In one example, children had been identified as specifically vulnerable through displacement induced by neighbourhood relocations, and the cushioning effects of social networks have been emphasised through storytelling (WS3/1, Pos. 226-229).

[61] Subsequently, the quotations will disclose the source data by referencing workshop number, document number and position in the document in the following style: WS3/1, Pos. 333 = workshop 3 / document 1, Position 333).

3.1.2 Performing Expertise

Stakeholder participation fluctuated throughout the process, with varying numbers present in each workshop. The core workshop group consisted of members from urban planning authorities, tenant associations, a resident, and a representative from property owners. While the main roles were represented, participants also **included perspectives from non-present roles**. Through their collaboration with actors in their field, they were aware of the requirements important to these actors. For example, a property owner contributed knowledge on building funding programs by federal investment banks (WS3/1, Pos. 358), and a member of a neighbourhood association provided insights on elder tenants (WS1/1, Pos. 109).

Participants **emphasised their experience** in the field, either in terms of years of service („After years of dealing with the subject matter (…)“, WS1/1, Pos. 89) or involvement in lighthouse projects that had received considerable publicity (WS1/1, Pos. 28). This performance of expertise became apparent in the starting phase of the project during introductory moments and more noticeably during controversial discussions (WS3/1, Pos. 364-366; WS4/1, Pos. 60-62).

3.1.3 Finding and making time

Participants' availability and willingness to participate in the workshops were strongly influenced by the time resources they had. Those invited in their professional roles were able to dedicate their working hours and were available on weekdays during office hours. Those invited based on their non-occupational roles had to find time during their leisure hours, often in the evenings. Participants with care responsibilities were more available in the mornings during school hours. Counsellors working with marginalised communities faced time constraints towards the end of the month due to the accumulation of legal actions related to leases ending. Most participants expressed regret over having **limited time** (WS1/1, Pos. 21 & 198). **Coordination of dates** thus became important, and workshop dates were timed according to participant’s availabilities (WS1/1, Pos. 198 & 199). Being pressed for time resulted in participants **leaving the workshops earlier or joining later** (WS1/1, Pos 67 & 188). **Last minute cancellations** resulted in important perspectives not being present in the workshops (WS1/1, Pos. 245).

The **willingness to clear their schedule** was also influenced by how well they understood the experiment and if they saw how they could achieve an impact by participating. One neighbourhood activist from the critical urbanism community declined his participation via email after attending the kickoff workshop, as he did not want to invest his limited time to a project he did not see value in:

I wanted to let you know that I can't (and don't want to, it's always a matter of priorities) afford to take part in the project any longer. (…) I don't really see where fundamental criticism or other approaches could be implemented or even discussed in this modelling project. (…) I don't have the resources for a small-scale technocratic discussion. (WS1/2, p. 1)

If participants understood the experiment well and saw how they could make an impact, or if the topic was relevant to their interests, they were more likely to clear their schedule for the workshops:

I know the next meeting is during my holiday. But if I were to be in Hamburg then, I would actually come to it during my holiday too, because I find it really exciting. (WS3/2, Pos. 18)

3.2 Twinning practices

3.2.1 Filling Gaps

Participants noticed and pointed out missing actors (WS1/1, Pos. 58; WS2/2, Pos. 195; WS3/1, Pos. 257-258). Some actors had not responded to the invitations (WS3/1, Pos. 257-258), had dropped out of the process (WS3/1, Pos. 12) others had cancelled their participation last minute (WS1/1, Pos. 14) or not shown up without further notice (WS3/1, Pos. 18).

However, the present participants made an effort to include those missing perspectives in the workshops. So did the tenant counsellor take on the role of economist (WS2/1, Pos. 195), or provided knowledge on tenant law (WS2/1, Pos. 165-166). And others pointed out the specific situation of elderly tenants (WS 1/1, Pos. 109). In a several instances, gaps in the built model were noticed by several participants at the same time, independently (WS2/1, Pos. 183-184).

3.2.2 Making explicit

Given the abstract practice of building a digital model, unclarity was expressed at times. Throughout the workshop, several practices of making explicit emerged, such as asking each other, explaining concepts, clarifying abstract notions, building coherence, specifying ideas, and reducing or extending complexity:

From the question that was there at the beginning to what we have worked out now, we have somehow made the problem less complex and at the same time it is still complex, but much more understandable. (WS2/2, Pos. 8)

During a simulation exercise in workshop 4, a scenario was selected to test the impact of a new policy capping the percentage of modernisation costs that could be transferred to renters. However, the results showed that the rent continued to rise regardless of the

policy setting. In testing which factor dominated the calculation, participants found that inflation commanded the rent increase more than any other factor. This instigated a discussion on missing factors in the model that could counterbalance inflation. The participants recognised the deceptive nature of the inflation factor and agreed to differentiate it into "pay increase" and "total price increase.“ The model did not only facilitate the testing of policy recommendations, but also made explicit which factors had been deemed of essence, and which had not been included, and the reasons why.

Participants expressed that through the simulation of the models, relevant and irrelevant strategies became apparent:

> And I believe that these models offer the possibility of a much better qualified exchange about individual aspects. (…) I think we can then somehow steer the discussion a little bit, so that we can say, ‚Are we going to talk about nothing here or are we going to tackle the big issues somewhere?‘ I think that could support something like that very well. (WS4/2, Pos. 3)

3.2.3 Quantifying uncountables

In the modelling process, participants faced the challenge of **quantifying abstract concepts** related to the nexus between energetic modernisation and gentrification through rent increase. Some indicators could be easily calculated (rent = net cold rent + utilities), obtained from available data sets (number of residents in selected neighbourhoods), or were fixed numbers that could be taken from statistical or public data (inflation level, average square metre rental price). Others, such as ‚knowledge on tenant law‘, ‚social networks‘, or ‚decision to relocate‘, proved difficult to quantify. To give an example: When discussing the indicators of a social network for the agent-based model, participants named the number of contacts, the level of efficiency of these contacts, the contacts in the right positions of power, the law competence of the contacts, and the number of advice centres (WS3/1, Pos. 253). Participants recognised the importance of including these factors in the model, even if their quantification seemed impossible. It was decided to model these concepts as fluid factors on a scale from low to high, acknowledging their influence on other factors.

3.3 Agency

3.3.1 Switching and staying in perspectives

Participants employed various strategies to address differing perspectives. Those included, but were not limited to, objecting, overruling, finding consensus, agreeing. However, in cases where conflicting perspectives emerged, **negotiation and constructive discussions** took place. For instance: During a mapping exercise, two opposing perspectives were negotiated. The perspectives of the representative of

proprietors, who focused on the profitability of modernisation measures, differed from those of the lawyers advocating and counselling for tenant rights, who focused on the affordability of housing. The group had identified “displacement” as an important process and was attempting to map out the individual process steps. The proprietor differentiated that this process would proceed differently for tenants than for residing proprietors, as tenants would face the result of rent increase, but residing proprietors would face the result of compulsory reconstruction with differing effects. The group decided to map two different processes for each stakeholder group (WS3/1, Pos. 306-313).

In the process, participants mentioned how they gained knowledge from each other (WS2/2, Pos. 3), but even more, that the process is suitable to teach about the complexity of urban planning:

> I found it very exciting to see how what we did in the morning now assembled. Sometimes I had difficulties to combine some things in a logical way. But I believe it is very difficult, because we chose two unbelievably complex questions. (…) And I learned a lot and found it very interesting to bring in all these facets and on the other hand reduce the complexity. (…) You could really sense today that urban planning is immensely complex. (WS3/2, Pos. 10)

3.3.2 Appropriating the process

Participants showed a strong interest in the topic and its potential impact, leading them to allocate time and effort to participate in the workshops. They expressed a **desire for new knowledge** to support their work and recognised the workshops as an **opportunity to connect with others** in their field (WS1/1, Pos. 18, 22 & 26; WS2/2, Pos. 3; WS2/1, Pos. 165-166; WS3/2, Pos. 3). They used the workshops as a platform to exchange information and connect on related projects. Specifically during the pauses, participants gathered around the catering area or in other areas of the room, exchanged on recent events relevant to their work, or connected on projects that needed updating (WS1/1, Pos. 19; WS3/1, Pos. 153).

Additionally, participants used the workshops to achieve their individual goals, putting their topics on the agenda and campaigning for modelling an ideal state. For instance when discussing the questions that should be modelled:

> (The important question is) who uses how much housing in the city. We are always told we need more housing space. What is disregarded there is, that social housing has clear guidelines regarding the number of square metres. But in owner-occupied housing there is no political control of how much space people use. This question would be important to me to depict in the model, because it is a question of justice. (WS1/1, Pos. 134)

3.3.3 Co-owning the product

The high relevance of the topic and the perceived possibility to create an impact can be described as one of the most motivating factors for participation. Participants mentioned their interest during the preliminary interviews as well as in the workshops (Documents 0/1, 0/2, 0/3, 0/4 and WS1/1). They captured the modelling states, requested documentation and screenshots for reporting purposes (WS1/1, WS2/1).

Participants **developed a sense of ownership** and took pride in the final product. Upon reflecting on the co-creative work, one participant said:

> I found it super constructive. I came here with relatively few expectations or few concrete ideas, and I find it amazing that we have now, let's say, got a model together. And it's interesting what you were able to contribute to it and what has become of it and what I was able to take away from all of you and what I found, yes, what I learned. (WS2/2, Pos. 3)

Two explicit moments of co-ownership became apparent throughout the end of the process. A tenant-lawyer reported about a federal assembly of their tenant alliance where they would like to present the tool in order to support their lobby work (WS4/2, Pos.18-22). Another participant employed by the ministry of housing and urban development showed interest in presenting the results to their partnering ministries in other German states (WS4/3, Pos. 13).

3.4 Reflexivity

3.4.1 Transparency & Trust

Building a digital model of a social process co-creatively is in itself quiet a complex and abstract undertaking. Turnout for participation might have been influenced by this, however the data to proof this is lacking as participants did not always share their reasons for not joining the experiment. Those participants who did take part, expressed how confusion turned into understanding, showing they held a **tolerance for disorientation** during the process: „I felt like the others – before I had a knot in my head – what do they want? – this has dissolved. I find it so great that I want to continue to participate.“ (WS 1/1, Pos 218

Holding the space for disorientation and guiding participants to the end helped to create trust in the process. This was aided by the transparent process structure:

> I did not only understand the question, I also won trust. In the way that; the clutter will dissolve eventually and I will have the insight. I found that incredibly terrific. (WS4/2, Pos. 22)

3.4.2 Designing for (dis)order

Following Voinov and Bousquet (2010), the process steps and a minimal structure were defined, which could be shuffled and allocated as needed. The overall time frame for the process was set from February to April, with three stages: Kickoff, Modelling, and Conclusion. The workshops took place in the showroom of the CityScienceLab in Hamburg, and the overarching topic was climate protection and social justice. Detailed decisions were made collectively, including continuously reformulating the research question and setting the scale, which impacted the process, such as transitioning from one model to two models and conducting separate modelling workshops.

For the researchers, the openness of the process was important to allow for emerging co-ownership. Various strategies were employed to provide stability within the open process. Before each meeting, a comprehensive information document was shared, outlining the process steps, previous workshop results, and the goal of the upcoming meeting. Meetings began with reading the agenda and introducing everyone, followed by presenting outputs from previous workshops and ending with a reflection round. Strict time management was implemented during the workshops to avoid exceeding the allocated time. Ample breaks were incorporated into the program for recovery and socialising, and catering was provided. Each workshop was followed by a summary of the results and an outlook on the next steps.

Participants admitted feeling confused at times and uncertain about the project's outcome, but they also appreciated the systematic agenda and strict timing as that provided a sufficient framework for productive collaboration (WS2/2, 3/2). By offering a stable framework, trust was established, giving stakeholders the security for experiencing confusion.

> It is a very complex topic and I had my problems imagining what would be the result. But the system you used was very helpful in structuring the steps and the result at the end. Even though it still looks very complicated, it has brought order to the whole thing. In a comprehensible way, where we could incorporate our, let's say, our knowledge. So the idea to make the development of such models more transparent, and people who are involved with it on a daily basis can give their input, I think that works well within this framework. (WS3/2, Pos. 11)

3.4.3 Open-Endedness

An element of Designing for Disorder was to design the process in such a way that it was open to changes. This way, participants had the agency to make alterations in the process, the timings, and the result. The process had to have this openness in order to allow for different models to be built in case participants were not agreeing with each

other. Only this openness allowed for a diversity of representation of reality. However, it also involved a higher level of organisation and trust.

When the co-creative process started, there was still uncertainty about the scale and number of models to be built, and thus, about the timeline of workshops. Without a pre-formulated vision of the resulting model, participants did not have a goal towards which to work and had to rely on the process and results emerging from it. While this was at times challenging, it allowed for constant input, influence and decision-making by participants who shaped the process and results.

> It is a very complex topic and I always had problems imagining what the result will be. But I find this system that you use, in any case, I think it structures it very well. These steps and what comes out in the end. Even if it still looks very complicated, it has brought order to the whole thing. In a comprehensible way, where we could incorporate our, let's say, our knowledge. So the idea is to make the development of such models more transparent and to allow people who are involved in it on a daily basis to give their input. I think that works well within this framework. (WS3/2, Pos. 11)

3.5 Analysis

The results outline how the four dimensions of co-creation are manifested in the twinning case study. They indicate that a careful design of co-creative twinning workshops and consideration in selecting stakeholders is required to open up space for communication and acting together, allowing for the emergence of trust, transparency and agency. The analysis of the case study highlights 6 lessons learned for co-creative twinning, which are discussed below indicating challenges and potentials that play a role in understanding and designing for co-creative twinning.

The importance of stakeholder selection and community: The process highlighted the significance of carefully selecting stakeholders based on their expertise, in order to include a diversity of perspectives. Participants socialised during pauses and workshops, forming alliances and coordinating their inputs. Trust and familiarity between stakeholders played a role in their decision to participate. Existing networks, personal and professional relations that extend the project runtime can be used to recruit diverse perspectives to the process. Designing workshops in a way that allows for socializing gives participants the possibility to catch up on projects and extend their personal and professional networks, acting as a motivating factor.

The influence of roles and motivation on participation: The availability of time resources significantly influenced participants' ability to engage in the co-creative process. Time resources depended heavily on the role participants had during the workshops. Participants' availability and willingness to participate in the workshops were strongly influenced by their motivation and role in the process. Allowing flexibility in

setting the timeframe was crucial, but it also required higher organisational effort and introduced uncertainties in the project plan. Understanding the impact of time availability on participation can help in designing inclusive processes that accommodate different stakeholders' schedules.

Setting a minimum framework to allow for (dis)order: This is a challenge both to practitioners as well as involved stakeholders, however it is a prerequisite to allowing diverse perspectives to be included, to appropriate process and product. In defining a minimum framework, co-creative twinning practitioners can create boundaries that help foster trust in the twinning group. In letting other aspects undecided, practitioners can support negotiation and collective decision-making.

Co-creative modeling helps making latent knowledge explicit: Participants acknowledged that the models facilitated more qualified exchanges and helped focus the policy discussions on key issues. The modelling process allowed for a better understanding of the complexity of the urban context and the concept of gentrification. Through practices of inquiring, challenging, explaining, objecting, advocating and building coherences, participants engaged in reifying notions of the urban. The model and the modelling process supported making implicit knowledge tangible in exposing hidden assumptions. This observation was also validated by the participants who emphasised frequently how the process helped grasp the complexity of the urban and of the selected concept of gentrification.

Coping with conflict and differing perspectives: Participants employed various coping strategies when faced with conflict and differing perspectives. In cases where conflicting perspectives emerged, negotiation and constructive discussions took place. The model facilitated this negotiation, reconfigured knowledge and perspectives, and broadened the design space. Understanding these strategies can help in designing future co-creative processes that foster constructive discussions and negotiation of different viewpoints.

Developing co-ownership of the model: Participants developed a sense of ownership and took pride in the final product. By actively participating in the modelling process, they gained a deeper understanding of the tool and its underlying assumptions. Stakeholders appropriated the process for their own goals and expressed ownership of the product, taking it into other contexts. This highlights the potential for co-creative processes to generate value beyond the immediate project outcomes.

3.6 Conclusion

The research shows that complex models for digital urban twins can indeed be modelled co-creatively. The four dimensions of co-creative twinning have been helpful in analysing the dimensions of co-creation, and the research describes emerging practices and requirements for stakeholder involvement as well as potentials of co-creative twinning. It also reflects on the challenges of employing these methodologies and pitfalls to be mindful of. Further research could focus on the concrete outcomes of these processes on digital urban twins, both in terms of the structure and quality of the resulting models, as well as the quality of the source code. How does data of socio-ecological topics translate to the models, and how is complexity visualised and debated? The author looks forward to expanding on these topics, deriving a framework for analysis and defining design principles for co-creative twinning, and encourages other researchers to test the framework in different twinning settings.

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