



DEMONSTRATION OF DIGITAL TOOLS TO SUPPORT PARTICIPATION IN MOBILITY

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GLOSSARY

EC	European Commission
EU	European Union
HR	Handlungsraum der Stadtentwicklung / Urban Development Action Area
IHRK	Integriertes Handlungsraumkonzept / Integrated Urban Development Plan
ISEK	Integriertes Stadtteilentwicklungskonzept / Integrated Urban Regeneration Implementation Plan
M	Project Implementation Month
NEB	New European Bauhaus
NEBourhoods	Creating NEBourhoods Together
NGO	Non-Governmental Organisation
NPL	Munich Neuperlach
OA	Open Access
T	Task
WP	Work Package
Organisation Name (Consortium)	
AGM	Architekturgalerie München e.V.
BYF	Bayerische Forschungsallianz GmbH / Bavarian Research Alliance GmbH
GC	Green City e.V.
HM	HM Hochschule München University of Applied Sciences
HM:UniverCity	HM Innovationsnetzwerk / HM Innovation Network
MGS	MGS Münchener Gesellschaft für Stadterneuerung GmbH
MS	UnternehmerTUM MakerSpace GmbH
MUC	Landeshauptstadt München / City of Munich
MUC CCI	Kompetenzteam Kultur- und Kreativwirtschaft / Team of Excellence for the Cultural and Creative Industries
MUC CULT	Kulturreferat / Department of Arts and Culture
MUC LED	Referat für Arbeit und Wirtschaft / Department of Labor and Economic Development
MUC PLAN	Referat für Stadtplanung und Bauordnung / Department of Urban Planning and Building Regulations
SCE	Strascheg Center for Entrepreneurship
STR	Str.ucture GmbH
SAAD	Studio Animal-Aided Design GmbH
SSR	Studio Stadt Region Forster Kurz Architekten und Stadtplaner Partg Mbb
TUM	Technische Universität München / Technical University of Munich
UTUM	UnternehmerTUM GmbH
Organisation Name (in Cooperation with)	
MER	Münchner Ernährungsrat e.V.
MIN	Münchner Initiative Nachhaltigkeit
OTH	Ostbayerische Technische Hochschule Regensburg
Organisation Name (Associated Partners)	
BDA	Bund Deutscher Architektinnen und Architekten e.V.
BDA-By	Bund Deutscher Architektinnen und Architekten Bayern e.V.
ByAK	Bayerische Architektenkammer, Körperschaft des öffentlichen Rechts / BAK – Federal Chamber of German Architects
BYD	Bayern Design GmbH

SUMMARY

This report is part of the deliverables of Creating NEBourhoods Together (2022-2025). NEBourhoods is one of the six lighthouse demonstrators of the New European Bauhaus funded by the EU to address the great challenges of climate, environment, and health. Combining co-creation and entrepreneurship while placing culture and creativity at the core of the transformation process, the project delivers accessible and empowering solutions to make the EU Green Deal beneficial for all in Munich Neuperlach and beyond.

The NEB Action “Mobility NEBourhoods” addressed the sustainable transformation of mobility in Neuperlach. For this reason, we designed and installed two physical NEBourhood Hubs based on a participatory co-creation process. These hubs are placed at nodal points of Neuperlach’s pedestrian network and combine mobility-related functions with general improvements for public space. Furthermore, we prototyped, implemented and evaluated a digital platform. This platform builds upon urban data from the Digital City Twin project of Munich and comprises several tools for the co-creation of NEBourhood Hubs.

This document describes how these digital tools were conceived and developed. Firstly, requirements for different participation formats and interactions were derived from experimental analogue co-creation formats with citizens from Neuperlach – drifting, urban photography, and model-building. Based on these learnings, we outline our vision for a participatory platform which uses the potential of urban data and digital media and – at the same time – incorporates situated perspectives and contextual learnings from Neuperlach. To realise this vision, we implemented several basic technological modules and created a set of digital participation tools on this basis. These prototypes are described with respect to their functionalities, their context of usage and resulting information. Furthermore, they were evaluated by citizens of Neuperlach. In conclusion, we discuss the potential of the presented approach as well as the resulting digital tools with respect to future planning projects.

1 INTRODUCTION

1.1 PROJECT OVERVIEW

“Creating NEBOurhoods Together” is one of the six lighthouse demonstrators of the New European Bauhaus funded by the EU to address the great challenges of climate, environment, and health. The aim is to collaborate on the European Green Deal to create more sustainable, inclusive, and beautiful living environments across the EU. In Munich-Neuperlach (NPL), one of Europe's largest post-war urban expansion areas, NEBOurhoods is collaborating with citizens and stakeholders from culture, science, and business to implement ten actions from all fields of urban development, encompassing circular construction and redesign of residential and commercial buildings, innovative forms of mobility and energy communities, biodiversity and green space concepts and nutrition and youth culture. Encouragement of entrepreneurial thinking and action and practical implementation in co-creative processes support the formation of sustainable neighbourhoods in liveable, inclusive, and beautiful cities of the future.

Combining co-creation and entrepreneurship while placing culture and creativity at the core of the transformation process, the project will deliver accessible and empowering solutions to make the EU Green Deal beneficial for all in NPL and beyond. The district will be carefully cultivated into a resilient urban innovation landscape. Within two years, we will create NEBOurhoods together and show how we can realise circular thinking and acting in society and the economy, activate the green transformation in building, mobility, energy, food and health and enhance public spaces.

1.2 OBJECTIVE OF THE “MOBILITY NEBOURHOODS” ACTION

The Mobility NEBOurhoods action contributes to the sustainable transformation of mobility in Neuperlach. As an intervention into existing traffic networks, we designed, installed, and evaluated two multifunctional NEBOurhoods Hubs combining mobility offers with context-specific community functions. These hubs were located, configured and co-designed through a participatory co-creation process with citizens and creatives. Additionally, we prototyped and implemented a digital platform consisting of several participatory tools supporting the co-creation of NEBOurhood Hubs.

1.3 ACTION TEAM

The action was led by a team at the chair of Architectural Informatics, consisting of experts from urbanism, digital design, and computer science and several student assistants. The co-creation process was developed and conducted in close collaboration with the TransitionHub

and MUniverCity. Additionally, three creatives from the NEBourhoods pool were involved in different co-creation formats. The NEBourhood Hubs were designed and produced by the enterprise Gronard GmbH in Neuperlach. Furthermore, the Münchner Gesellschaft für Stadterneuerung (MGS) supported the implementation and maintenance of the hubs.

1.4 OBJECTIVE OF DELIVERABLE 5.6: ADAPTED DIGITAL TOOL FOR PARTICIPATION

In this report, we document the prototyping and implementation of a digital platform that includes several tools for the co-creation of NEBourhood Hubs. These tools utilise data from Munich's Digital Twin project and make this information available in a participatory context. Furthermore, they respond to the requirements and learnings gained from analogue workshops and collaborative formats. Based on these insights, we outline our concept for a digital toolbox that responds to situated learnings and concrete steps of a participation process. We implement a platform of several foundational technical modules and digital participation tools. Finally, we describe the testing of these tools in Neuperlach and discuss their potential for future usage in civic participation.

2 MOBILITY IN NEUPERLACH

Considering the future sustainability of Neuperlach, the mobility transformation represents a central challenge. The Integrated Urban Development Plan (IHRK) as well as the Integrated Urban Regeneration Implementation Plan (ISEK) consider “traffic and mobility” one of the central topics for the development of liveable and sustainable urban space (Legeland et al., 2021, p. 56 or Landeshauptstadt München, 2021). A strict separation of traffic modes, of pedestrian and car networks, characterises the late modernist estate. Following the urbanistic theme of the “gegliederte und aufgelockerte Stadt” (structured and scattered city), the original master plan favours one-fits-all solutions and optimisation for car traffic. The Ständlerstraße and several multi-lane streets structure the district of Neuperlach, and parking spaces are dominant in public spaces. At the same time, the ratio of cars per citizen is below the motorisation average of Munich (Legeland et al., 2021, p. 56).

A large pedestrian network extends between these streets and is detached from the main roads via sculptural bridges, which seem to be generally ignored by Neuperlach’s Pedestrians. This disposition causes long ways for pedestrians and barriers for citizens with mobility impairments. While the IHRK asserts a specific spatial quality to the pedestrian network, there are many barriers for strollers or wheelchairs and challenges in terms of orientation (Legeland et al., 2021, p. 58). This is especially problematic with respect to the high ratio of elderly citizens as well as young families (ibid.). Furthermore, concerning gender dimensions, many paths are poorly lit and unwatched, leading to a low feeling of safety, especially at nighttime (ibid.). Moreover, the IHRK asserts that the general availability of public transport is good. However, public transport stations lack integration in the street spaces and squares and are partly not barrier-free (Legeland et al., 2021, p. 62). New transportation offers like bike sharing are underrepresented in the area (Legeland et al., 2021, p. 64).

As we learn during NEBourhoods, the district’s mobility disposition is far more complex than the original modernist masterplan assumes. Mobility is experienced very differently by several social groups and stakeholders. Mobility is related to unexpected practices like hacking shopping carts. The topic involves dealing with mobility impairments and collective grief for lost public furniture. Mobility does not only concern traffic but also local communities, the beauty of public spaces, and sustainable ways of living.

Intervening in this domain means dealing with a classical “wicked” problem (Rittel & Webber, 1973), requiring collaboration with multiple stakeholders and negotiating between conflicting perspectives. According to Pim Peter’s study of traffic planning in Munich, many tools, standards and indicators for mobility planning are rooted in an automobile-centred modernist planning tradition (Peters, 2019) – in the same era as the original masterplan of Neuperlach. Hence, the challenge is not only reorganising mobility infrastructure but also remaking the instruments and tools of mobility planning. The action Mobility NEBourhoods sets out with the following question: How can we create tools incorporating underrepresented perspectives and new forms of collaboration on mobility in Neuperlach?

3 CO-CREATION TOOLS FOR MOBILITY NEBOURHOODS

The action Mobility NEBourhoods consists of two complementary parts: On the one hand, we installed two physical NEBourhood Hubs through a participatory co-creation process. On the other hand, we prototyped, implemented and evaluated a digital platform¹ for co-creation and participation. This platform comprises several digital tools for the co-creation of NEBourhood Hubs. This report documents the conception, creation and evaluation of these digital tools.

The NEBourhood Hubs are located at nodal points of the pedestrian network – one close to the metro station of Therese-Giese Allee (RESI-Hub) and the other at Steinplatz (STEINI-Hub). These multifunctional hubs combine mobility-related functions (like a shared cargo bike or a repair station) with improvements for public spaces (e.g., a comfortable space to rest or the possibility of borrowing sports equipment). The co-creation, installation and evaluation of these NEBourhood Hubs are described in the NEBourhoods deliverable D5.5.



Figure 1 Installed NEBourhood Hub at Therese-Giese-Allee. Image Source: NEBourhoods/Nick Förster

¹ In this context, the term platform signifies a modular collection of different digital tools for participation as well as several foundational technological modules. Our vision is further elaborated in chapter 3.3.

As a decentral and multifunctional infrastructure, the NEBourhood Hubs must react to the concrete needs of the local neighbourhood. Implementing the hubs sustainably – and making sure that they meet the residents' actual needs – requires the inclusion of various stakeholders' knowledge through a participatory process. To support such processes, we provide a digital platform for participation and collaboration. Specifically, we aim to combine innovative co-creation approaches with digital media and urban data. We experiment with interdisciplinary collaborations between planners, computer scientists, and artists to include diverse stakeholders, shape co-creation experiences, and explore new aesthetic perspectives on urban spaces.

The NEB action builds upon the Digital City Twin (Landeshauptstadt München, 2024), which is an ongoing initiative of the municipality. Our action demonstrates use cases and concrete concepts and how information from the Digital Twin can contribute meaningfully to participation in the context of sustainable mobility and liveable public spaces. The Digital City Twin project is not to be understood as a single technology but rather an ecosystem consisting of an “Urban Data Platform,” multiple urban data sets from different contexts of planning and governance, as well as several use cases. The latter include tools and analyses for urban planning and methods for digital participation. Thus, establishing new media like Extended Reality and simulations meaningfully in participatory contexts has been an important part of the Digital City Twin initiative. The municipality highlights that the development and implementation of digital technologies must go hand in hand with civic participatory and bottom-up engagement (Connected Urban Twins, 2024).

By fitting our action in, we have a strong link to the Digital City Twin project. On the one hand, we developed different approaches to how data from the Digital City Twin can be meaningfully used in participatory tools for mobility planning – both conceptually and technically. We developed methods for integrating urban data sets into prototypes based on Game Engines (see Chapter 4 and the Technical Annexe). Furthermore, we demonstrated practically, using different prototypes, how this data can be used in a participatory situation (See Chapter 4). Through this part of our action we explored the potential of using data and approaches from the “Digital Twin” initiative as a foundation for participation in urban planning. On the other hand, the action shows how to tailor digital tools to specific planning projects, relate to the concrete conditions of a neighbourhood and combine quantitative and qualitative insights from a participation process. In this context, the development of digital tools should not be seen as the development of technical solutions but rather as a co-creative activity that addresses contextual issues and mediates between different stakeholders. In this way, the action contributes to a strategy that combines analogue and digital formats in new ways.

The results are being discussed with experts involved in the strategies of the Digital Twin and the Smart City in Munich for future developments and collaborations. In this way, we ensure that the methods and tools developed contribute to the future development of the Digital Twin in a sustainable manner. We thus contribute concepts and previous work developed at the

TUM Chair of Architectural Informatics in projects such as Game.Up², Urban Strategy Playground³ or CDP/Collaborative Design Platform⁴ to the growing discourse around Digital City Twins.

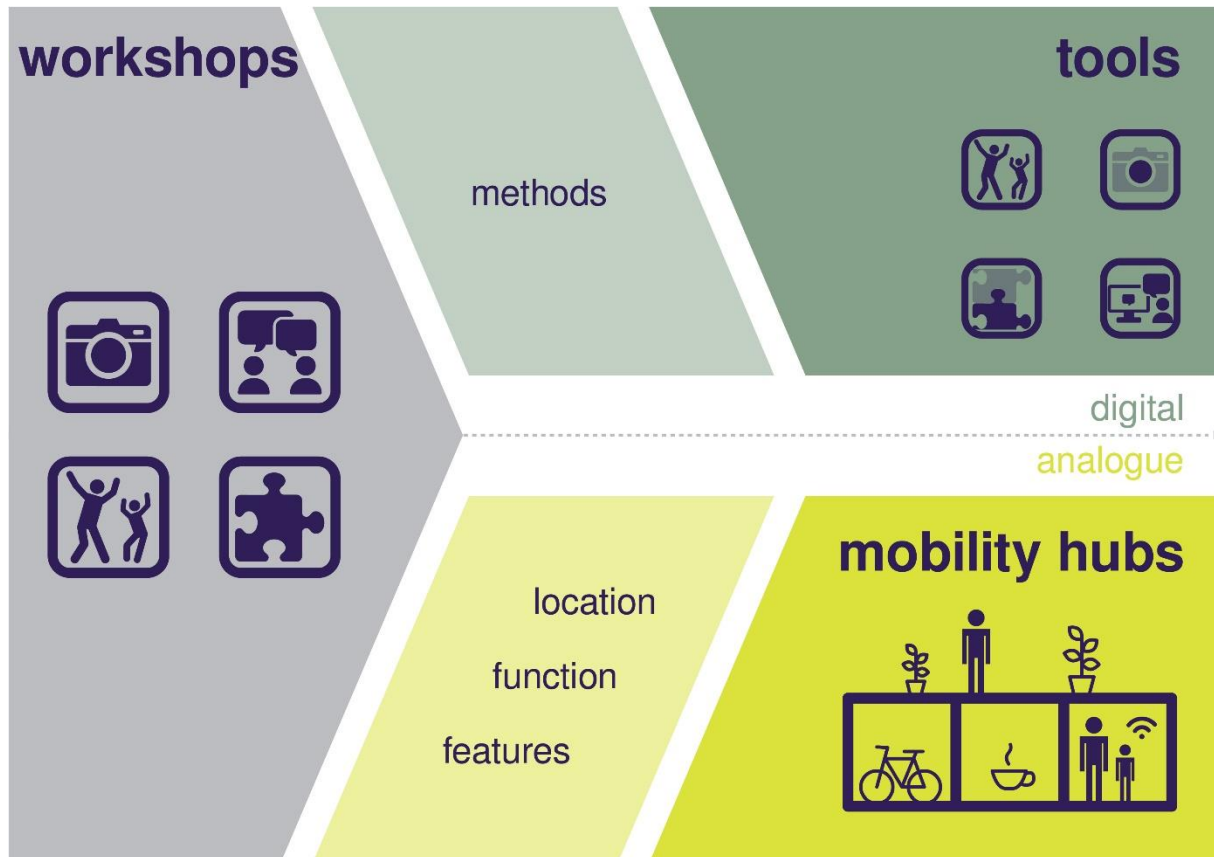


Figure 2 Parts of the Mobility NEBourhoods action.

The aim of this report is to document the conception and design of digital tools that support the co-creation of NEBourhood Hubs. Our initial approach included a gamified configuration app that allowed citizens to create proposals for NEBourhood Hubs and vote for specific options. Based on these requirements, two mobility hubs were to be established. However, it soon became apparent that this approach would not fit with the intense focus on open-ended co-creation within the NEBourhoods project. In discussions with the Transition Hub team, it was repeatedly criticised that a simple configurator could not enable meaningful participation about mobility in Neuperlach. A tool that was developed exclusively in a university context would ultimately fail to include local perspectives and would be burdened with problematic biases. This critique corresponds to critical voices on digital participation and gamification (Gabrys, 2016, 236 pp.). Hence, the initially proposed configurator appeared too universal

² <https://www.arc.ed.tum.de/ai/forschung/digital-participation/gameup/>

³ <https://www.arc.ed.tum.de/ai/forschung/collaborative-design/usp-urban-strategy-playground-2016-2019/>

⁴ <https://www.arc.ed.tum.de/ai/forschung/collaborative-design/cdp-collaborative-design-platform/>

and too limited in this context. We identified the risk that the tools developed would not allow for an adequate level of participation and therefore could not be reused in future projects.

In response to these relevant concerns, we focussed on an adapted strategy for the development of digital tools. We paid particular attention to contingent outcomes and local perspectives on mobility. This approach was developed in close collaboration with the Transition Hub team and artists from the NEBourhoods pool of creatives. Together, we discussed how digital tools could integrate the core principles of the NEB: How can we explore aesthetic experiences of participatory interactions? How can the tools enable new forms of inclusive communication and collaboration? How can we achieve new relevant perspectives on sustainable mobility in this way? In close cooperation with the abovementioned creative professionals, we designed and implemented several experimental participatory formats to enable open-ended co-creation of NEBourhood Hubs. In additionally, these formats allowed us to learn about key aspects of NEBourhoods co-creation formats and how to combine analogue and digital participation methods in new ways. Thus, these formats became a crucial foundation for the development of digital tools that integrate central perspectives from Creating NEBourhoods Together. This included the Transition Hub members proposing to include co-creation perspectives and collaboration in the design process of participation tools.

At the same time, these decisions required an adapted process for the action. Learning from co-creation experiments and opening the tool development process required more time than just implementing a simple configurator. The co-creation process of the Hubs and the design of tools had to go hand in hand instead of sequentially: Figure 2 shows the relationship between the development of a digital participation platform and the installation of two NEBourhood Hubs. Both parts built upon a co-creation process involving several participatory workshops with residents of Neuperlach. Through these formats, we collected possible locations, functional configurations, and design ideas. At the same time, conducting these activities was crucial for developing the digital tools for civic participation. Instead of introducing a pre-determined understanding of civic participation in specific aspects of mobility planning, the goal was to apply an open-ended co-creation approach also to the design of digital tools. This method should include situated knowledge and citizens' perspectives in developing digital tools. Moreover, this method involved an interdisciplinary collaboration between architects, computer scientists, participation experts, creatives, and artists. In this way, the resulting digital tools did not directly contribute to the design of Hubs. Instead, they integrated crucial learnings from this process, which can be reused for future projects. In the future, it will be central to bringing both of these processes together so that concepts and tools developed can be used for participation programmes. In Chapter 7 (Conclusion and Outlook), we will discuss the steps to achieve this result.

In the following chapter, we will describe how these co-creation formats helped to form a vision for a platform of digital toolkits for participation in mobility. Thus, we will explain how

specific learnings regarding the co-creation of NEBourhood Hubs, as well as qualitative observations on collaboration and exploration, became central requirements for the prototyping of digital tools. On this basis, we introduce our vision for a digital platform comprising foundational technology modules and digital toolkits for participation. We describe and evaluate the resulting collection of digital participation tools in Neuperlach. Finally, we discuss the potential of the presented prototypes and approaches to react to situated mobility problems, engage local communities through playful, creative formats and shed light on different aspects of the mobility transformation.

As an overall result of the “Mobility NEBourhoods” action, we aim to provide a replicable framework for situated interventions in mobility infrastructure. Firstly, we offer a situated participation toolkit to support this process and an approach to adapting these tools to different contexts. Thus, we provide a co-creative strategy for implementing context specific NEBourhood Hubs (see D5.5).

3.1 CO-CREATION PROCESS

The co-creation process was conceived and conducted in close collaboration with the TransitionHub, an institution consisting of HM UniverCity and the City of Munich's Team of Excellence for the Cultural and Creative Industries. This TransitionHub is responsible for the participation and collaboration processes within NEBourhoods. Through co-creation workshops, we aimed to engage with local citizens at a grassroots level. Additionally, these formats involved interdisciplinary collaborations with actors from the art and creative domains. Three creatives from the NEBourhoods pool – the dancer Ralf Otto, the photographer Sandra Singh, and the architectural designer Enrica Ferrucci, led the workshops and contributed their specific artistic expertise. By this, we aim to delve into the aesthetic and experiential dimensions of co-creative activities and open up new perspectives on mobility. Through a selection of creatives with a strong focus on social inclusion, we aimed to open up the process for heterogeneous groups of stakeholders. For instance, Enrica Ferrucci has experience in workshops with children, while Ralf Otto works on dance projects with elderly participants. In this document, we introduce these workshops only briefly and with respect to the development of the digital platform. A discussion with respect to the co-creation of NEBourhood Hubs is found in the NEBourhoods Deliverable D5.5.

3.1.1 Workshop: Multimodal Drifting

In this workshop, large-scale and small-scale localisation were combined through collective movement through urban space. The format was developed with Ralf Otto, a local dancer, who already had experience with “drifting” as a collective practice of spatial and social exploration. During the workshop, the participants roamed the selected area on foot and by bike to find the best potential locations for two envisaged NEBourhood Hubs. Firstly, the participants were introduced to the workshop’s objectives and rules: both by bike and on foot, they were supposed to move slowly and stay very close to each other. One person could

take the initiative and lead the group in a direction they find interesting. The same principle was used to decide whether to cycle or walk. If the group agreed on a potential location, this was recorded using geo-referenced POIs. In conclusion of the workshop, it can be stated that Drifting bears some real potential for finding spaces on a small scale in a co-creative way. Also, it gave us the opportunity to experience the urban space intermodally and empathise with other people's perspectives and ideas. The result is an intermodal travel chain and a collection of suitable locations.



Figure 3 Warm-up exercise of the drifting workshop. Image Source: NEBourhoods/Matti Drechsel

3.1.2 Workshop: Photographic Data Gathering

This format was hosted in cooperation with the local adult education centre (VHS Munich) and was developed with the photographer Sandra Singh. It started with a free urban photography workshop for Neuperlach residents. Consecutively, they were introduced to a photo competition which ran for two weeks. The task was to identify places in Neuperlach that are crucial for future mobility and to take creative pictures of them. Also, participants had to reason for their choice through writing or sound recording. Afterwards, all images were localised on a neighbourhood map and evaluated in a discussion round with local planning experts. While the number of competition entries stayed behind our expectations, the overall format introduced some fascinating aspects regarding the collaborative search for hub locations. The workshop established a very welcoming atmosphere and introduced photography as a collective engagement with urban spaces.



Figure 4 Explorative photography exercise. Image Source: NEBourhoods/Nick Förster

3.1.3 Workshop: Collaborative Model Building

Together with Enrica Ferrucci, a local architect working with design-centred pedagogy, we held a workshop focusing on the configuration and the design of individual hubs. In the first phase, cardboard cubes were covered with pictures, collages, or symbols representing various functions. Multiple configurations were produced by stacking and combining these cardboard cubes. Also, the interactions between different functions were discussed. At the end of the first phase, the participants weighted the functions using sticky dots. Based on this voting, the most critical functions were then built on a scale of 1:20 in the second workshop phase. Wooden parts, plastic rings, and paper constructions were used for this. This allowed us to concretise various functions and check for feasibility. In addition, the participants developed designs that best support the respective function.



Figure 5 Model-building workshop. Image Source: NEBourhoods/Matti Drechsel

3.1.4 Workshop: Negotiating Decisions

Finally, we compiled information collected in the previous workshops and presented it in a decision-making format. Additionally, several maps with analytical information on the mobility infrastructure were provided (e.g., from the IHRK and the ISEK). People sat in a circle around a large tarpaulin with an aerial photograph of Neuperlach. Besides local citizens, we invited the creatives from our previous workshops, as well as members of municipal departments, to these workshops. Together, we went through the results of participation workshops and compared suggestions for the localisation and functional configuration of the NEBourhood Hubs. During the workshop, different variants for hubs were put together. In the end, all participants in the workshop were asked to vote for one alternative.

3.2 REQUIREMENTS FOR THE DESIGN OF DIGITAL TOOLS: LEARNINGS FROM ANALOGUE FORMATS

While digital tools for participation are a relatively new phenomenon, there is a long tradition of analogue tools and creative formats, which are common for participatory and collaborative processes. Creative, artistic and sometimes activist methods of bottom-up processes range from building kits, urban exploration exercises, and role plays. In recent years, analogue

participation methods have increasingly embraced artistic engagements and open-ended forms of expression. Notable participation initiatives, such as Hamburg's "Planbude", integrate various forms of contingent expression, including collective drawing and modelling, with open discussions and playful activities within urban spaces (Tribble et al., 2017, p. 271). Approaches like this situate the process in specific urban environments, fostering improvisation and the inclusion of diverse and sometimes unexpected stakeholder perspectives.

In this chapter, we describe the requirements for the design of digital tools that we have derived from our analysis of the analogue participation experiments described above. The first set of requirements concerns different levels of co-creative decision-making and the required results for implementing NEBourhood Hubs. These requirements define relevant formats of usage for digital participation tools as well as relevant information types.

The second type of requirement addresses the methods of collaboration, exploring urban spaces and gathering ideas. These qualitative insights into the experimental participation formats become requirements for the user interactions and aesthetical aspects of the participation tools. Also, these artistic approaches to collaboration and data gathering serve as a source of inspiration for innovative and “creative” ways in which digital tools can support public participation.

3.2.1 Steps, Formats and Results for Co-creating NEBourhood Hubs

Each mentioned workshop introduced a specific form of co-creation, differing in terms of the decisions to be taken, information to be gathered, scale to operate on, and time frame to work together. Photography exercises over a longer period allowed participants to explore sites all over Neuperlach and contribute to the large-scale localisation of NEBourhood Hubs. On the contrary, drifting provided a relatively short, local experience, allowing us to explore smaller areas in more detail and gather qualitative information on local mobility issues. Model-building helped us to configure the functions of the hubs and gather input for the concrete design. Learning from the participation process, we defined the following four information types, which should be covered by workshops and participatory tools. These “co-creation-requirements” have been introduced in our previous article “Situating digital Participation” (Drechsel et al., 2024).

Large-Scale Localisation: Identifying optimal locations for NEBourhood Hubs across an entire district presents several problems. It's essential to establish clear criteria for selecting the most suitable sites. To avoid bias, decisions based solely on a participant's place of residence or neighbourhood should be avoided.

Small-Scale Localisation: After deciding on a general location for an NEBourhood Hub, the next step is to define a specific site. This involves factors such as traffic regulations, pipework, ground loads, and clearance areas. Additionally, the proximity to different facilities

and design concepts must be taken into account. The challenge lies in reconciling these two sets of factors - the hard, technical constraints and the soft, qualitative aspects.

Configuration of Functions: The hubs can serve diverse functions, but these must be tailored to the specific needs of each location and respond to the local context. Hence, the task is to find approaches that allow us to collect, compare, and discuss the desired configurations. Additionally, it's important to discuss an operator model and concrete steps for implementation.

Design: How can small-scale ideas such as bookshelves or lockers be integrated into the hub design? What are the concrete requirements of the place? What ideas do residents have about colours and materials? The respective participation format must encourage residents to be creative and, at the same time, convey the technical limitations and necessities.

3.2.2 Learnings about Interactions, Aesthetics, Experiences

In addition to requirements regarding the results of each tool, we aim to learn from the process and experiences of artistic co-creation formats and incorporate these aspects into digital tools. As we have established before, the target is to incorporate the essential dimensions of interaction and aesthetical experiences that we encountered during the analogue co-creative workshops. We were predominantly interested in approaches which would allow new ways of interacting with each other (collaborating, communicating, reasoning), as well as perspectives which would enable new perspectives on urban spaces (exploring, mapping, narrating). With respect to the NEB-Compass, these criteria highlight the principles of “Together” and “Beautiful.”

We concluded six central dimensions from the diverse learnings of the workshops. While this list is by no means exhaustive, we determined these aspects as especially productive in shedding new perspectives on mobility and allowing specifically productive interactions in the workshops. These different categories have been previously discussed in the article “Situating digital participation” (Drechsel et al., 2024).

Bodily Movement: The drifting workshop emphasised bodily movement. Nonetheless, physical motion was also an important dimension of the photography workshop. Different exercises encouraged participants to explore urban spaces in unconventional ways, such as discovering previously unknown areas or focusing on the materiality of the ground. Moving together via drifting also enhanced a sense of potential mobility impairments or specific movement preferences.

Group interactions: Collective activities, such as model building and drifting, highlighted collaborative interactions and a joint result—whether it was a model or the experience of a drift. These participation formats acted as catalysts for open-ended discussions and allowed the building of a sense of community and trust.

Interactions with the environment: Photography tasks require participants to position themselves and their cameras in relation to the urban surroundings. Drifting, as a form of physical exploration, also involves negotiating where people can and cannot go, as well as bodily engagement with the materiality of urban spaces.

Mapping: An essential aspect of the drifting workshop was exploring spaces in a structured manner and graphically representing the gathered information. This approach enabled groups to discuss and shape spaces that would have been difficult to comprehend otherwise. Putting images on a map had a similar effect.

Design Interactions: The model-building workshop utilised design interactions and physical making as a catalyst for discussing various aspects of mobility. This approach also helped to prioritise different functions for NEBourhood Hubs.

Feelings: All workshops complemented the generation of classical quantitative information, with individual perspectives on urban spaces. The formats included storytelling, subjective experiences, corporeal sensation, and aesthetic aspects. These dimensions were crucial in how stakeholders related to mobility issues and presented their viewpoints.

3.3 VISION: A PARTICIPATORY PLATFORM AS SITUATED TOOLBOX

We shaped our vision for a digital participation platform through the insights described above. Soon it became evident that a single online portal or a hub configurator cannot fulfil the heterogeneous – but inspiring – requirements derived from the co-creation process. Instead, we propose a toolbox which involves *multiple participatory interactions*, reacts to the *concrete context* of co-creating in Neuperlach, and builds upon *reusable technical modules*.

Firstly, the developed tools should cover all relevant “stages” of co-creation described in 3.2.1: Large-scale and small-scale positioning, configuration of functions and gathering design input. The co-creation formats did not only target different results but also involved different time scales and forms of collaboration: Model-building occurred in an intense workshop session of a single afternoon. Also, the photography approach included an in-person session, whereas the consecutive competition lasted over two weeks.

At the same time, the workshops facilitated diverse experimental perspectives and engagement with mobility and urban spaces. Specific aesthetic experiences – like bodily movement, capturing a beautiful image or making an interesting model – were crucial in this regard. Furthermore, the formats enabled different forms of collaboration. Model-building, taking pictures together, and drifting around Neuperlach involved fascinating social interactions, and contributed to a sense of togetherness between the participants. These experiences also led to an interesting combination of qualitative and quantitative information.

For instance, Drifting opened up a comfortable frame for sharing personal stories about mobility, while it also produced geo-located suggestions for placing NEBourhood Hubs. Each interaction had its own merits and highlighted a specific form of exploration or collaboration. This corresponds to the complex nature of mobility on Neuperlach and multiple related perspectives. For this reason, we decided against a single technological system or online platform in favour of a modular toolkit, which could react to multiple experiences and forms of co-creation.

Furthermore, the workshop formats gained from adapting them to the context of Neuperlach and a close engagement with local problems. For instance, as a dance instructor often working with elderly persons, Ralf Otto's drifting workshop sheds light on mobility impairments and movement challenges in NPL and should highlight the perspectives of the elderly persons who represent a large group of stakeholders in NPL. Instead of a generic digital platform, we aim to create tools that emerge from and can react to such contextual aspects.

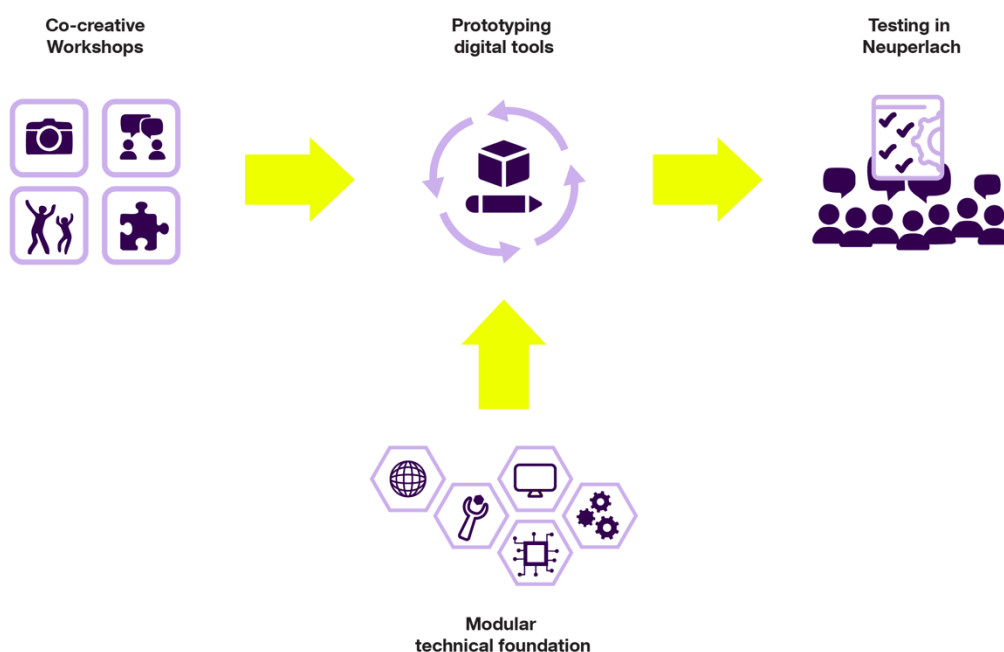


Figure 6 Vision for making a situated participation toolbox.

For these reasons, we decided to focus on a toolbox consisting of several digital tools. Each would correspond to a specific context of usage, provide a specific experience of co-creation, and provide different information. Instead of replacing the analogue co-creation formats, which we deemed as very interesting, the tools should rather be embedded in similar approaches and complement them. For instance, an Augmented Reality application would not be developed as a stand-alone application but in the context of a workshop.

At the same time, it would be inefficient to implement the different tools as isolated prototypes. Thus, all tools should be built upon shared resources. For instance, all tools should use geo-data from the city's "Digital Twin" project or provide data which could later be visualised and analysed in this context. Furthermore, the tools would share functionalities like user interactions and interface features. Hence, the developed digital platform should include a technological foundation of stable and reusable components. These components would allow the prototyping process to react more flexibly to the idiosyncrasies and contexts of concrete co-creation formats.

This setup is also reflected in the interdisciplinary collaboration within the Mobility NEBourhoods action. Several computer scientists were selected to prepare the technological platform, whereas the architects and planners of the team focussed on the prototypes in collaboration with students of architecture and urbanism, the TransitionHub, and the creatives from our co-creation workshops. This vision was first introduced in the paper "Situating Digital Participation" (Drechsel et al., 2024).

As the diagram above shows, the process of implementing the participatory platform occurred in the following steps: Through analysing and experiencing the experimental workshop formats, different requirements for digital tools were defined. Based on these requirements, a technical foundation of several modules was implemented. In an iterative prototyping process, we juxtaposed learnings from the experimental workshops with digital media and technologies (like GPS-tracking, Mixed Reality, or different forms of data visualisation). Through this process, an array of digital toolkits was produced. Finally, these emerging prototypes were evaluated in Neuperlach.

4 A MODULAR TOOLBOX OF DIGITAL TECHNOLOGIES

Several technical modules should allow the fast and flexible prototyping of several digital tools for participation. This foundation should consist of stable and reusable elements, whereas the digital tools building upon them would be more context-related and emerge through an open-ended and interdisciplinary prototyping process.

The technical requirements for the foundational components came mainly from two directions. On the one hand, the tools should be built upon geo-data from the Digital Twin project of Munich and integrate some basic functions to present and process this data. Other requirements were defined with respect to co-creation formats as defined in Chapter 3.2. Based on this analysis and our expertise from related research projects, we selected several promising digital media and technological elements. For instance, we included GPS functions and Mixed Reality features to incorporate central aspects like bodily movement and the interaction with urban spaces. Additionally, the technical toolbox should provide assets and design-related features that support the creation of high-quality prototypes and compelling interfaces.

As a basis for the creation of different prototypes, we chose the environment of the game engine “Unity”⁵. Choosing this platform provided us with a relatively intuitive environment for the prototyping of tools. Game engines offer an extensive range of features like user interface elements, 3D visualisations, or Mixed Reality features. While we are interested in working with open-source alternatives like Godot⁶ in the future, in this case, we preferred the commercial environment of Unity due to its easier usability, large community and superior support of features like Mixed Reality (at the time of writing).

In the context of this game engine, the computer science experts within the Mobility NEBourhoods team created modules for the following geo-data functions:

- Geo-localisation of objects
- Geo-data importer (exemplarily implemented for Geo-JSON files)⁷
- Querying metadata for objects⁸
- Finding nearby objects

Additionally, the technical foundation included templates, example code, and assets for the following functions:

⁵ Unity Technologies, *Unity Packages List*, <https://docs.unity3d.com/Manual/PackagesList.html>

⁶ Godot Engine, *Godot Asset Library*, <https://godotengine.org/asset-library/asset>

⁷ Mapbox, Mapbox for Unity, <https://www.mapbox.com/unity>

⁸ Unity Technologies, *Asset Metadata*, <https://docs.unity3d.com/2023.2/Documentation/Manual/AssetMetadata.html>

- Augmented Reality⁹
- GPS-location
- User interactions and interfaces¹⁰
- Sets of mobility-related 3D assets

Providing tutorials and didactic formats to access and combine these tools were a central part of this work. Thus, designers and users who are more familiar with co-creation formats instead of being experts in computer science could use these foundational models in their prototyping process. A more detailed description of these modules and functions can be found in the annexe of this document. Furthermore, the results and the prototypes are available via gitlab and can be accessed using the following link:

<https://gitlab.lrz.de/nebourhoods>

Of course, during the prototyping process, additional technical requirements emerged, and new components, tutorials and features had to be added. Thus, the modular foundation should not be seen as a fixed system but rather as a living collection of technical elements, resources, tutorials and instructions through which our technical team supported the prototyping process.

⁹ Unity Technologies, *ARCore XR Plugin Manual*,
<https://docs.unity3d.com/Packages/com.unity.xr.arcore@4.1/manual/index.html>

¹⁰ Unity Technologies, *XR Interaction Toolkit Manual*,
<https://docs.unity3d.com/Packages/com.unity.xr.interaction.toolkit@3.0/manual/index.html>

5 PROTOTYPING DIGITAL PARTICIPATION TOOLS

Several digital tools were prototyped on the foundation of our technical modules and learnings from the co-creation workshops. In the following section, we describe our prototyping process. Consequently, we give an overview of the resulting digital participation tools before introducing each single prototype in more detail.

5.1 PROTOTYPING PROCESS

We initiated the prototyping process with an academic design studio. Thus, we introduced thirty Bachelor's and Master's degree students from Architecture and Urbanism to our topic. This group went through the process of creating digital tools as described in Chapter 3.3. Firstly, we introduced the studio to the co-creation formats. We discussed requirements and learnings based on these experiences. Furthermore, the students learned how to discover the topic of mobility through different lenses and explored different forms of collaboration, exploration and discussion. Secondly, the computer scientists in our Mobility NEBourhoods team introduced the group to the game engine Unity, programming basics and how to use the different elements of our digital technology modules (as described in Chapter 4).

Based on these resources, we conducted ideation workshops aimed at bringing together the requirements and learnings from the co-creation workshops with promising technical elements. For instance, an interest in bodily movement and telling the situated stories of local citizens were translated into a location-based game using GPS-tracking and visualising geodata. This process was supported through exchange with the creatives and experts from the TransitionHub team. Through several stages of prototyping, these initial concepts were implemented as tools with the help of our computer science experts. Finally, these projects were presented as toolkits, comprising the actual tool as well as clear instructions on how it would be used in a workshop or a participatory format. In conclusion, the design studio provided us with an array of nine exemplary prototypes. After the semester studio, these exemplary prototypes were developed further. Minor adaptations through our team were necessary to make the tools run consistently on test devices.

The digital tools were developed as working prototypes. As we have outlined in 3.3, it was more central to translate learnings from the co-creation process and think of innovative ways how to support co-creation formats with digital tools than to create single, highly polished applications. Hence, the digital tools were intended to be working prototypes which focus on demonstrating a central function in the context of a specific participation format. Peripheral features, like saving data automatically to a database or logging into a user profile, were significantly reduced since they could often be handled with a workaround or analogue instructions (e.g., by registering workshop participants in person if necessary or by saving data manually).



Figure 7 Prototyping session with artists and students. Image Source: NEBourhoods/Nick Förster

5.2 A DIGITAL TOOLBOX

Through the prototyping process, a toolbox of diverse participation media emerged. In the following section, we give an overview of this toolbox. The categorisations of the different tools have been introduced in a previous article (Drechsel et al., 2024).

Firstly, a central goal was to cover all necessary steps of “co-creation”, as described in chapter 3.2.1. As we can see in the diagram below, the emerging prototypes addressed all steps from “large-scale localisation” to “Designing the hub”, through different levels of participation – gathering information, participating by contributing opinions or ideas, and lastly, collaborating in more open-ended formats. This scale was introduced with reference to Arnstein’s “Ladder of Participation” (Arnstein, 1969). While some prototypes just ask for submitting relatively simple information (like a short comment, or a simple interaction like a star ranking, or just the location), others ask for deeper participation (like positioning specific items and giving an opinion). Some prototypes even target closer and more open-ended forms of collaboration (as we find in a contingent design workshop). In general, the

prototypes aiming at larger-scale localisation, gather data in more passive ways, while the small-scale placement of hubs, configuring functions and gathering design ideas require more open-ended and complex forms of interaction (here labelled as participation or collaboration). While most tools focus on a specific task, some prototypes, like AR-Canvas (a tool which allows the placement of GPS-located elements through an Augmented Reality Interface), also cover several forms of co-creation. While tools for information gathering work in asynchronous ways (e.g., a tool which you use repetitively over a longer period) and focus on single users, tools for collaboration are to be used in groups and benefit from being deployed in collective workshops.

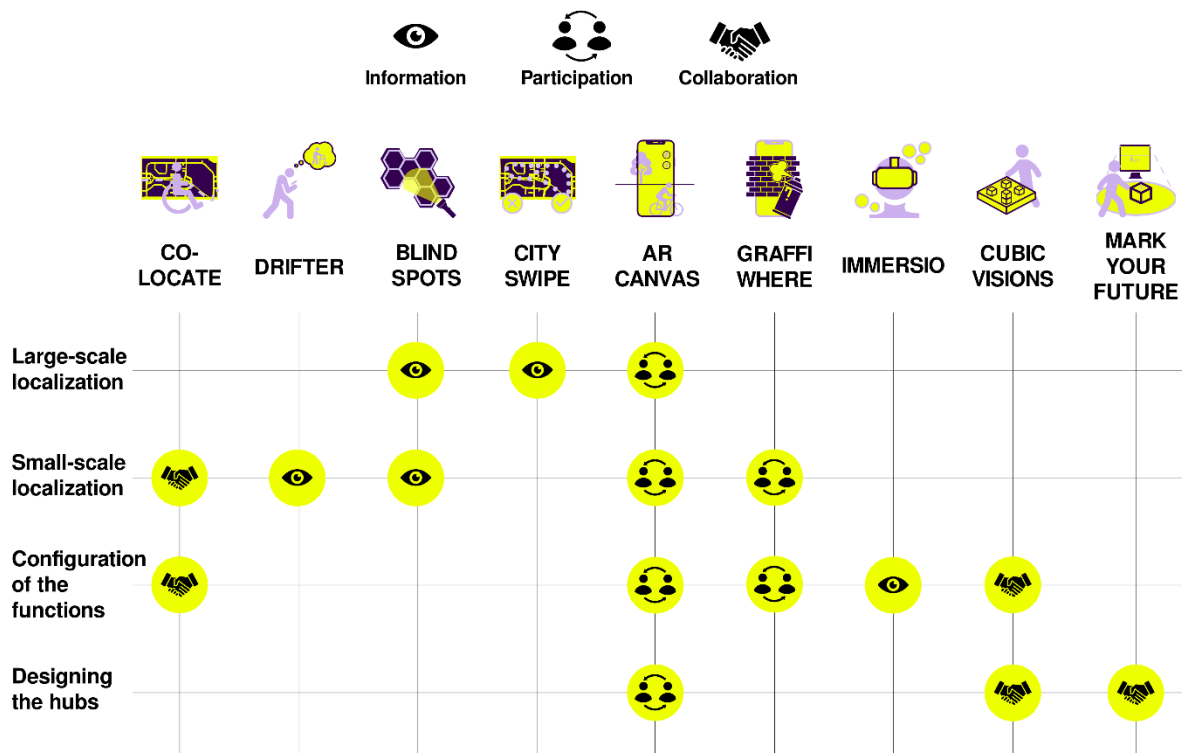


Figure 8 Usages of different tools.

Furthermore, we would like to give an overview of how the learnings from our co-creation formats influenced the conception of different tools and how these perspectives were implemented using digital media. We will summarise some commonalities from this process: In general, several tools combined Bodily Movement and Interaction with urban spaces. These requirements were implemented mainly using Augmented Reality(AR) and GPS-location tracking. Design interactions (creating a spatial solution) were another feature that was implemented either by creating elements in an AR scene or by interacting with tangible interfaces (like large cubes in the AR Canvas project). Gamification and usage of game elements were recurring features of many prototypes. One of our central learnings from the workshop was that playful interactions could provide an engaging experience for participants. While all prototypes used spatial data as input or output, especially for tools working on larger scales (Drifter, City Swipe, AR Canvas), geo-data functionalities were crucial.

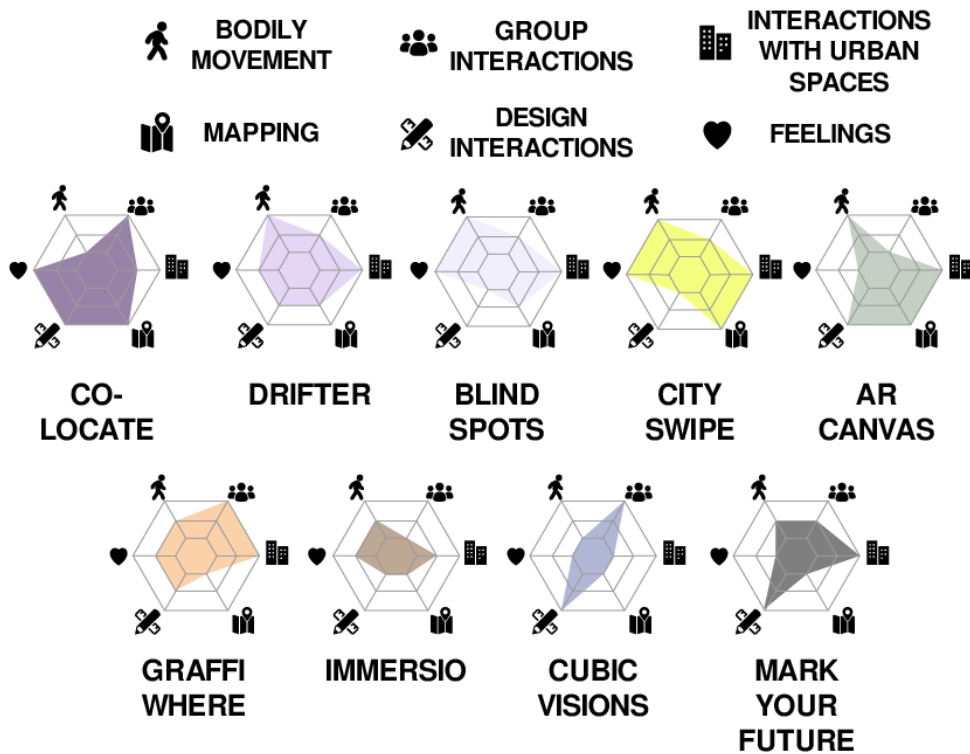


Figure 9 Incorporation of learnings from analogue formats into digital tools.

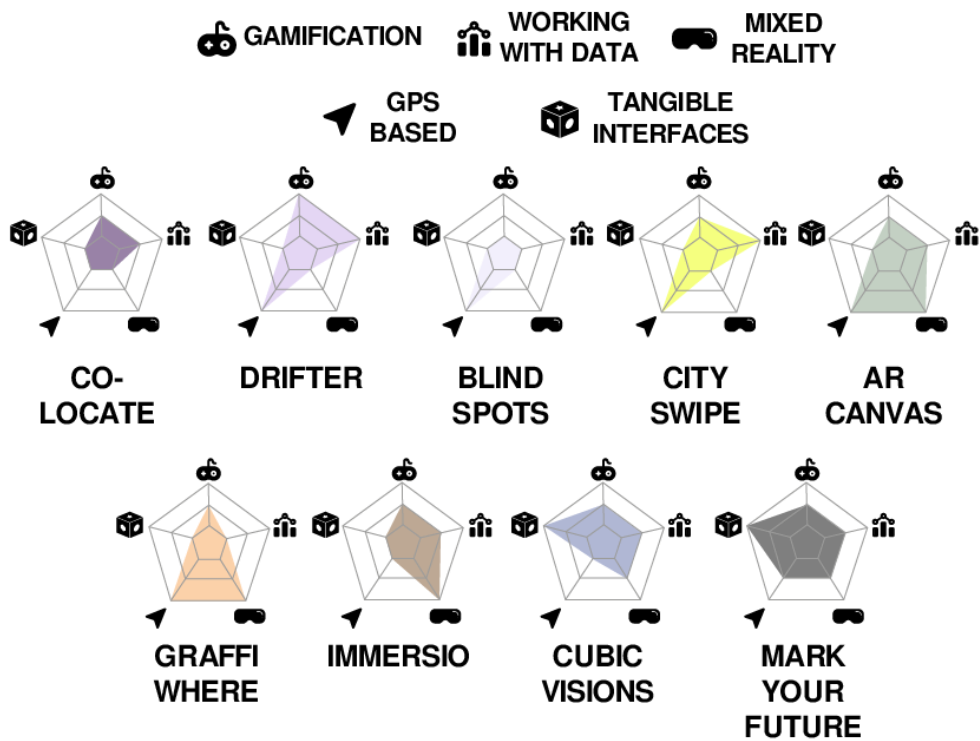
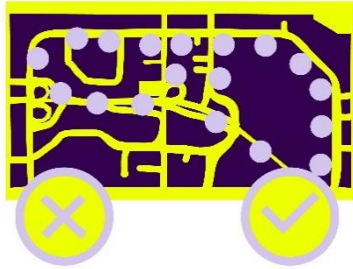


Figure 10 Digital technologies and methods used by prototypes.

5.2.1 City Swipe



Summary: City Swipe is a mobile phone app that collects information and opinions on potential hub locations. When a user passes by a potential hub location, they are asked to give their opinion on that spot with a swiping interaction as familiar from several dating platforms. Thus, feedback is gathered in a subtle and effortless way.

Context of usage: Individual usage over a longer time period (after introduction).

Function: Large-scale localisation

Key Components: GPS-Tracking, Gamification

Team: Bruna Gerling, Carolina Meirelles, Gony Amir, Paula Von Houwald

Concept and Research: CitySwipe is a mobile phone-based app that aims to collect data through GPS tracking with little effort from the user. With a simple swipe right or left, citizens can show their opinions about different places in a city. The tool sets out with the question of how a participatory process can be unrolled more widely by offering a subtle way of contributing opinions during everyday journeys. Thus, it is based on foundational research on how to gather both quantitative and qualitative data simultaneously. Besides the explorative workshops with creatives in Neuperlach, several social media and dating platforms were analysed as a subtle way of data-gathering. This research resulted in the concept of combining walking around the city in everyday situations and “swiping” as a simple mode of opinion-giving.

Usage: Users need to enable GPS-location tracking and start tracking their daily routes (only saved locally). When they pass by a potential hub location, they receive a notification asking them to contribute their opinion on this location. The application sends a notification with a picture and a category. The app then contains six different categories to be rated by the swiping mechanism: Cleanliness, accessibility, safety, community, greenery and quietness. The users are supposed to rate the place according to the category, swiping right for a positive and left for a negative answer. For example, if the place users are passing through is badly maintained, they can swipe left for the “Cleanliness” category. Apart from swiping, the user can also type in an open comment about the place.

Additionally, the app provides different types of information to the user. For instance, it presents the user's previous routes and allows them to check the overall ranking of different locations by all users.



Figure 11 Prototype City Swipe. Image Source: prototype team

Resulting Information: CitySwipe gathers not only quantitative data - a yes or no for each category – but also qualitative data – ideas, explanations and comments gathered through the commenting functions. All gathered data on the dots can be visualised in a map format as average, while the individual comments come in handy when analysing an individual spot in more detail. This could be useful for city planners to understand the potentials and challenges of different urban areas from a citizen's view. For planning processes, this data can be essential when it comes to identifying weaknesses or unsafe spots or getting a general opinion on an area.

Link to Github-Repository: <https://gitlab.lrz.de/nebourhoods/cityswipe>

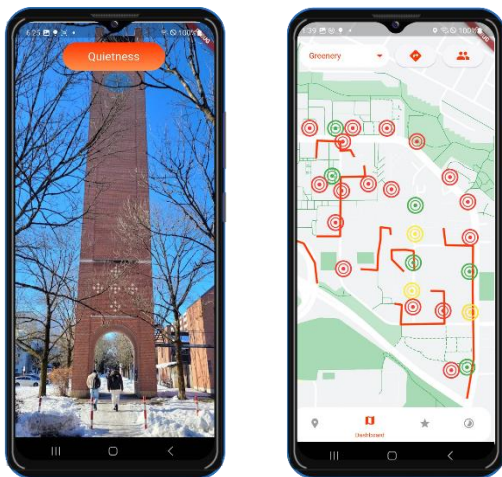
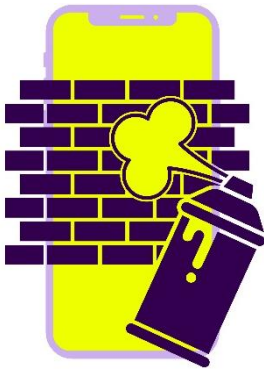


Figure 12 Screenshots City Swipe. Image Source: prototype team

5.2.2 GraffiWhere



Summary: The tool translates graffiti spraying into a mobile-phone-based Mixed Reality experience. Participants react to mobility-related questions by “spraying” 3D graffiti with their smartphones. Hence, they engage with urban spaces, gather ideas and mark problems.

Context of usage: Guided workshop, individual usage after introduction.

Function: Small-scale localisation and configuration of functions

Key Components: Augmented Reality, GPS Tracking

Team: Mariam Suwwan, Taiane de Melo Nepomuceno, Chenyuan Wang

Concept and Research: Graffiwhere aims to collect 3D drawings as a form of expression from citizens in order to understand their wishes and thoughts. The application is an augmented reality tool that enables users to spray urban 3D paintings in an Augmented Reality experience. The application was designed in Unity to be implemented on an Android or an iPhone.

The tool is inspired by learning about collective bodily movement from the drifting workshop and the photography workshop as a visual form of investigating urban spaces. Furthermore, the prototype team investigated the local graffiti subculture in Neuperlach – which appeared as a subversive and creative way of appropriating urban spaces and addressing specific urban problems. The tool GraffiWhere aims to adapt this activity as a participatory activity of creatively engaging with urban spaces, highlighting problems and collectively discussing ideas.

While the app is currently implemented as a tool for a single workshop, with more resources, the prototype could also become a multi-user platform, turning public areas into interactive forums, facilitating communication between residents and planners, and fostering a sense of community.



Figure 13 Prototype Graffiwhere. Image Source: prototype team

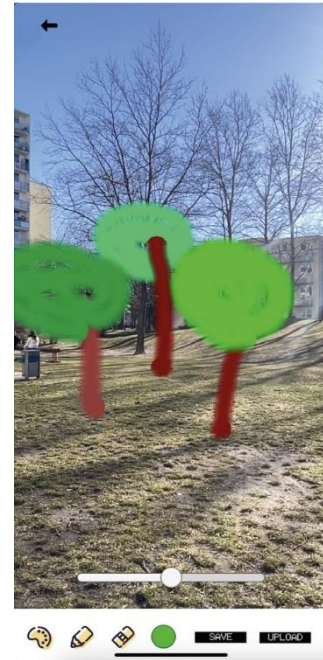


Figure 14 Screenshot Graffiwhere. Image Source: prototype team

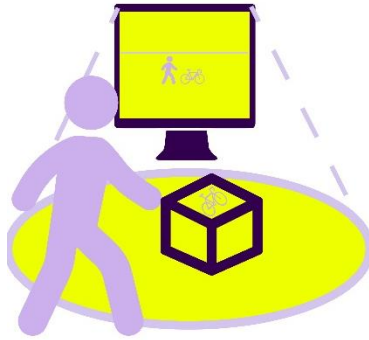
Usage: The application needs to be opened in a place (e.g., a street or square) which is subject to the participation process. Using the tool in a workshop is beneficial for assisting people with augmented reality interactions and connecting the tool with a collective discussion. The application opens in the “draw” mode: users move the phone like a spray can to create 3D graffiti. A simple interface allows one to adjust the stroke’s thickness and colour as well as switch to an eraser to remove errors.

Once the drawing is ready, it is necessary to save the result. Due to technical restrictions concerning stable AR-tracking between multiple devices, each graffiti is saved through a GPS-referenced screenshot instead of a 3D model. Especially since interesting graffiti reacts to specific features in urban spaces (e.g., add something to a sign or building part), this is the currently most realistic option. Considering future technological development in Augmented Reality, ideally, 3D graffiti could be uploaded and made visible on other users' devices.

Resulting Information: After a workshop, it is possible to investigate the 3D graffiti of other participants via each other’s devices. Furthermore, resulting graffiti (currently saved as geo-referenced screenshots) can be placed on a map and discussed together. This map visually provides an overview of the area and shows ideas in a playful and provocative way, underlining the positive and negative aspects of a site. The focus of this project is, however, not gathering a high quantity of machine-readable information, but rather opening a new perspective of collective investigation and an experimental co-creative experience.

Link to Github-Repository: <https://gitlab.lrz.de/nebourhoods/graffiwhere>

5.2.3 Mark Your Future



Summary: A media column equipped with a screen and a camera is installed at a potential hub location. Users play with physical markers, which are detected by the media column. On-screen, the markers are exchanged with physical objects. Hence, users can configure the location with different objects and contribute to a hub design.

Context of usage: Spontaneous individual and collective usage on site.

Function: Configuration of functions and designing

Key Components: Augmented Reality, Tangible Interfaces

Team: Lisa Ableitner, Alissa Schulteß, Anna Zieziula

Concept and Research: The tool builds upon research on how intuitive and material interactions provide a basis for co-creation. Furthermore, the team investigated how to give a compelling and understandable visualisation of co-created design variants. Hence, the team investigated tangible interactions (e.g., with physical objects controlling virtual objects) and augmented reality as a way to provide intuitive and playful visualisation for collaborative discussions.

Usage: A media column is placed at a potential hub location and allows for playing with different functional and spatial configurations via augmented reality. The column consists of a computer screen with a camera and paper cubes, each working as a distinct Augmented Reality marker, which is recognised by the camera. Users can assign different mobility-related 3D objects (e.g. a cargo bike or a repair station) to the markers. The screen turns into a virtual mirror: The screen mirrors what the camera records – however, the marker cubes are replaced by the respective 3D objects. Thus, users can visualise their designs on the screen in real-time. Also, they can “contribute” their design by actively saving a screenshot.



Figure 15 Prototype Mark Your Future. Image Source: NEBourhoods/Nick Förster

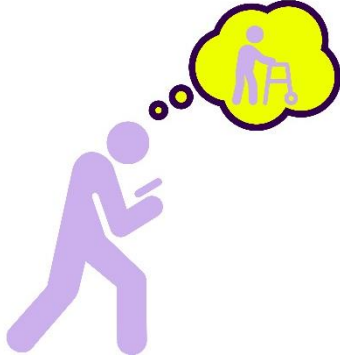
Resulting Information: The tool targets a playful and immersive design interaction. Like GraffiWhere, Mark Your Future allows visually simplifying the presentation and understanding of ideas in a funnier way, highlighting both positive and negative aspects. The prototype is installed at a location for a longer time frame and gathers information for a longer period. From the resulting configurations, planners can analyse specific wishes for the area. At the same time, it works as a method of building awareness and attracting attention to a specific project.

Link to Github-Repository: <https://gitlab.lrz.de/nebourhoods/mrk-your-future>



Figure 16 Screenshots MarkYourFuture. Image Source: prototype team

5.2.4 Drifter



Summary: The prototype is based on interviews with Neuperlach residents and aims to shed light on social aspects of mobility. Drifter translates these experiences into a simple location-based game for smartphones in which you explore urban spaces and place mobility-related items.

Context of usage: Configuration of mini-games in workshops and through interviews. Gaming as individual experience or as preparation for mobility-related workshops.

Function: Small-scale localisation

Key Components: GPS-Tracking, Gamification, Working with Geo-Data

Team: Justine Morin, Wen-Shan Cui, Buket Göksen

Concept and Research: Drifter aims to highlight different social groups' perspectives on mobility, such as experiencing barriers because of mobility impairments or the experience of many female persons feeling unsafe walking home at night. The project begins with research on these concrete perspectives. The team worked with interviews and a questionnaire-based survey with Neuperlach residents to identify focus groups and situations requiring attention and to understand their needs. The target is to get a deeper insight into situated mobility experiences and central parameters in public spaces (e.g., benches or lighting). Drifter encodes these perspectives into a simple mobile GPS-based urban exploration game – which allows users to immerse into a specific group's mobility experience and investigate urban spaces through this perspective. For the prototype, the perspective of an elderly person was implemented – the challenge is that this person walks through the city but requires places to rest. However, public furniture like benches are hard to find in Neuperlach (since they were broadly removed in the 1990s).

Usage: During the game, the user strolls through the district and has to reach a specific facility (e.g., a social facility or a shop). First, the player needs to press start and walk around an undefined route. Whenever they pass by a bench (registered by the app in a geo-data set), the energy level on the top left bar will recharge. If there are no benches available in real life, the user can place a limited amount of virtual benches, so the energy level is up again.

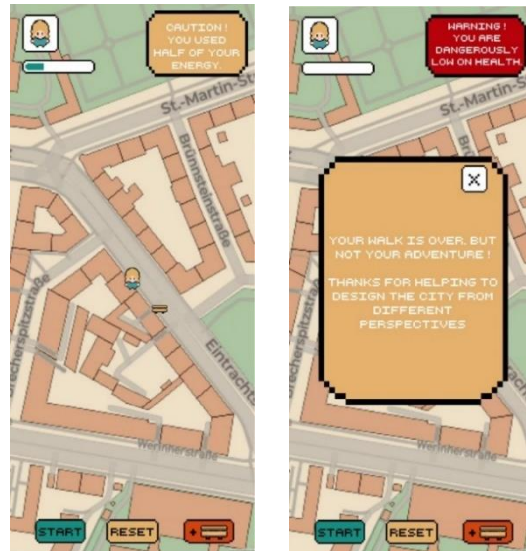


Figure 17 Prototype Drifter. Image Source: prototype team
Figure 18 Screenshots Drifter. Image Source: prototype team

Resulting Information: In this case, the game collects information on missing urban furniture, which can be helpful for urban planners. However, this is not the main function of “Drifter”. Instead, configuring scenarios for the simple game through interviews – or potentially in future collaborative workshops – and then enacting these perspectives through urban exploration – allows new perspectives on mobility and innovative ways of collaboration. Making and playing these games could be part of a co-creative analysis, a preparation for other collaboration formats, and a way of building awareness.

Link to Github-Repository: <https://gitlab.lrz.de/nebourhoods/drifter>

5.2.5 Co-Locate



Summary: Several users interact with a cartographic interface and map mobility challenges and barriers. Based on this information, they suggest hub locations.

Context of usage: Collaborative workshop or individual

Function: Small-scale localisation and configuration of functions

Key Components: Working with Geo-Data

Team: Yun Lou, Maximilian Schulte, Xiaochen Sun, Yuan Zhang

Concept and Research: Co-Locate is a collaboration tool specifically directed towards users of mobility-aiding devices (e.g. wheelchairs or strollers) or those experiencing mobility impairments. During the research process, the team investigated the challenges of public spaces in Neuperlach from the perspective of users of mobility-aiding devices. They navigated the neighbourhood in a wheelchair, discovering that efficiency factors such as speed, time, and distance are not the primary concerns for people with disabilities. Instead, comfort and accessibility, particularly the quality of surfaces, are more crucial. This experience highlighted the need to scale the project and collect feedback from these minorities to better address their needs.

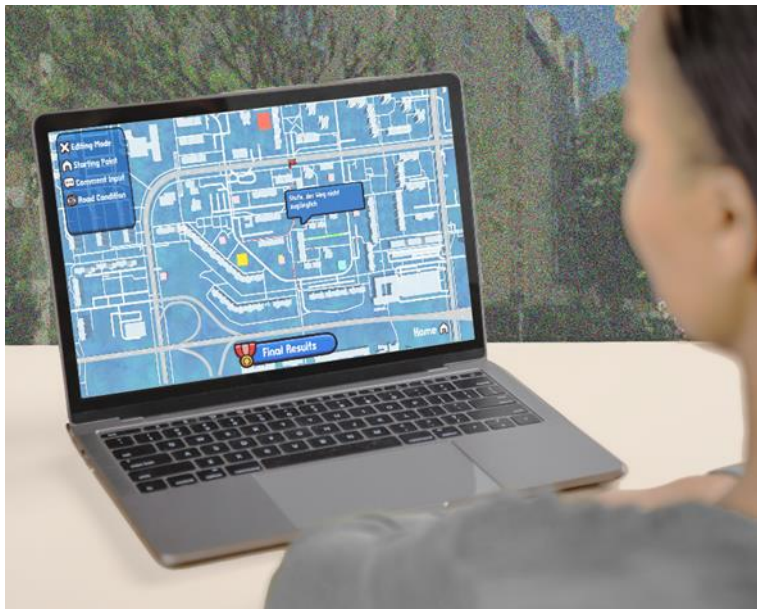


Figure 19 Prototype Co-Locate. Image Source: prototype team

Usage: Co-locate is a desktop application for collaborative workshops. The interface shows a big map and should be presented on a table via a touchscreen to allow simple interactions for multiple collaborators. Using the applications, participants begin by drawing their everyday routes on the shown map. They can choose different colours to classify it: red means a very bad part, orange for a moderate part and green for a good part. Afterwards, participants add a hub in a location that is suitable based on their experiences. In the end, they rank the location of other hubs and click „Final Results” to check the outcome.

Resulting Information: The tool not only collects direct information about routes and potential hubs but also encourages a structured discussion. Users can share their experiences and explain why they felt a certain way about specific parts of the route. This feedback allows urban planners to gain deeper insights into potential problems in various areas of the city, making them more aware of the community’s needs.

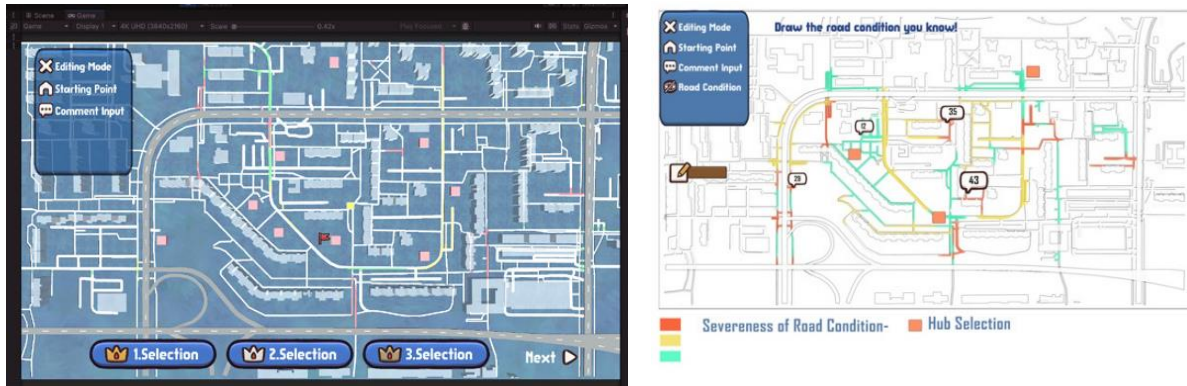
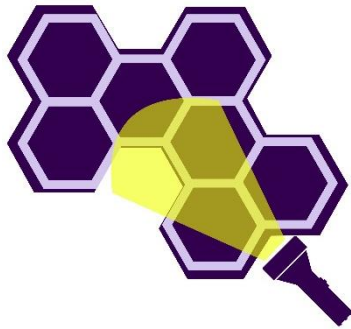


Figure 20 Screenshots Co-Locate. Image Source: prototype team

5.2.6 Blind Spots



Summary: Through geo-data analysis, so-called Blind Spots that lack coverage of mobility infrastructure are detected. These areas are further investigated with a participation app.

Context of usage: Individual usage over a longer period of time or during a mapping workshop.

Function: Large-scale and small-scale localisation

Key Components: Working with geo-data, GPS-tracking

Team: Luisa Herklotz, Jana Liszewski, Nicola Pfennich, Charlotte Schöffend

Concept and Research: BlindSpots gathers individual needs about places which are “unseen” from a mobility point of view - areas with bad traffic network coverage and relatively low obtained information on mobility. To learn more about these areas, the tool collects neighbourhood stories from citizens. Firstly, the BlindSpot areas were identified by analysing accessibility data using the GOAT program of TUM¹¹ and plan4better. The analyses involved assessing factors such as proximity to transportation hubs, availability of sidewalks and bike lanes, and the presence of barriers such as steep terrain or busy roads. Based on this initial analysis, the team created a mobile phone-based app that gathers information on these areas in several creative ways.

Usage: First, users choose a “BlindSpot” that they want to discover and go to this specific location. Being arrived, the app poses several explorative challenges. First, it asks the participant to explore the site for a few minutes and asks you to type a characteristic word. Next time, it asks for a sound and, lastly, for a photograph. Finally, they can either repeat the process or see the other user's data.

Resulting Information: The application encourages residents to discover and explore places they might have never seen or experienced. It highlights areas that may not have received enough attention from residents and urban planners. By collecting and sharing information about these locations, the app collects information on these sites. Users can access data shared by others, creating a collaborative platform that benefits both urban planners and citizens by highlighting potential improvements and fostering community engagement.

Link to Github-Repository: <https://gitlab.lrz.de/nebourhoods/blindspot>

¹¹ Chair of Urban Structure and Transport Planning, TUM, *Development of a digital accessibility tool for balanced spatial and transport planning (Goat 3.0)*, <https://www.mos.ed.tum.de/en/sv/forschung-und-beratung/projekte/bmdv-projects/goat-30/>



Figure 21 Prototype BlindSpots. Image Source: prototype team

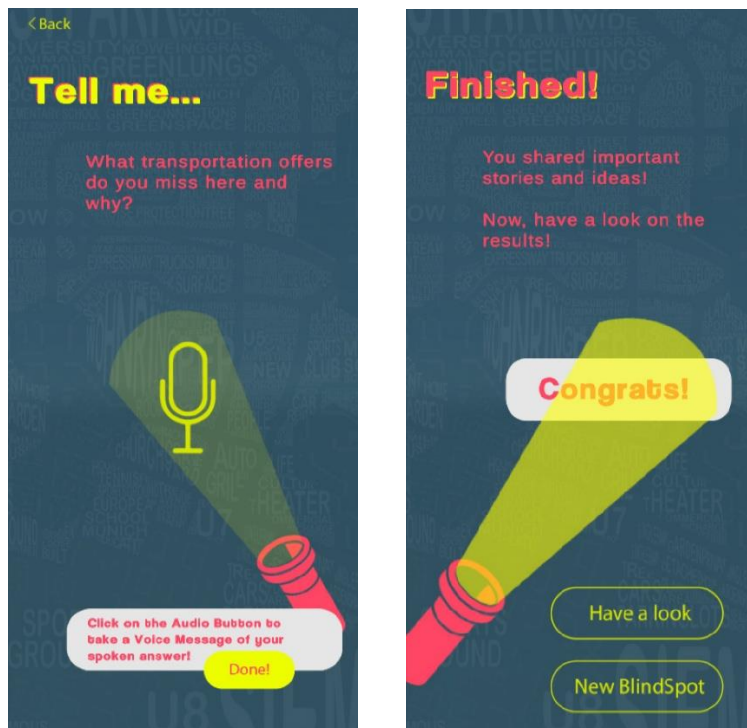
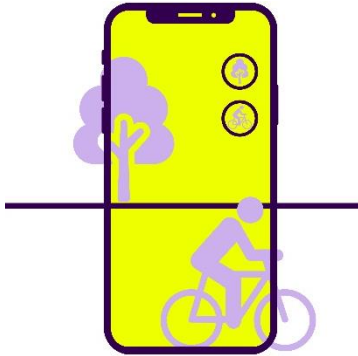


Figure 22 Screenshots Blindspots. Image Source: prototype team

5.2.7 AR Canvas



Summary: This mobile-phone-based prototype allows users to position 3D objects in an Augmented Reality Scene. Placed objects are saved with their respective GPS location. This allows both the individual creation of proposals and a geospatial analysis of several users' results.

Context of usage: Usage during a mapping workshop and individual usage after an introduction.

Function: Small-scale localisation, configuration of functions, design.

Key Components: Augmented Reality, GPS-tracking

Team: Agi Hidri, Neziha Ismail, Julia Węgrzyn, Viktoriia Yurzinova

Research and Concept: AR Canvas collects users' design suggestions for urban spaces and NEBourhood Hubs through augmented reality interactions. The prototype takes the form of a mobile game, where users can add objects to different subregions of Neuperlach. In the end, the idea is that the gathered data could be visualised in the form of a 2D map. Therefore, the AR interacts with the urban environment around and creates input on a small scale, while the final map is large scale. The tool is based on research on gamification and critical play. Furthermore, after analysing Neuperlach and discovering dark tunnels and empty streets, the team wanted to address feelings of safety and pedestrian comfort. Also, many residents told us stories about missing urban furniture, playgrounds and seatings, which had been removed in the past and were never replaced. Based on this investigation, the tool "AR Canvas" should allow citizens to improve functions like sitting opportunities, street infrastructure, etc.

Usage: First, users choose a pre-defined challenge in the app, like changing a specific area nearby or improving a specific aspect such as security. Next, an AR scene opens. The app allows users to select 3D items from an object library and place them in the Augmented Reality Space. Each placed item is saved with its GPS position. Thus, users place virtual objects (e.g., pedestrian crossings, public furniture, or vegetation) in public spaces to make suggestions for specific improvements. After being satisfied with the design, it is necessary to press the "check" button and finish the experience. In the end, a map can be generated with all the location data created by the users placing different objects (however, this last part is not implemented).

Resulting Information: The resulting information can be gathered and visualised on a map. Planners can either look at individual contributions or visualise all contributions as a heatmap or point distribution of different suggestions. This allows for finding patterns in several contributions. By placing objects related to safety, aesthetics, or comfort, participants contribute not only to their needs but also suggest a specific problematisation. Therefore, the

app can be helpful for urban planners in further development of Neuperlach by pointing out weaknesses as well as expectations from the inhabitants.

Link to Github-Repository: <https://gitlab.lrz.de/nebourhoods/ar-canvas>



Figure 23 Prototype ARCanvas. Image Source: prototype team

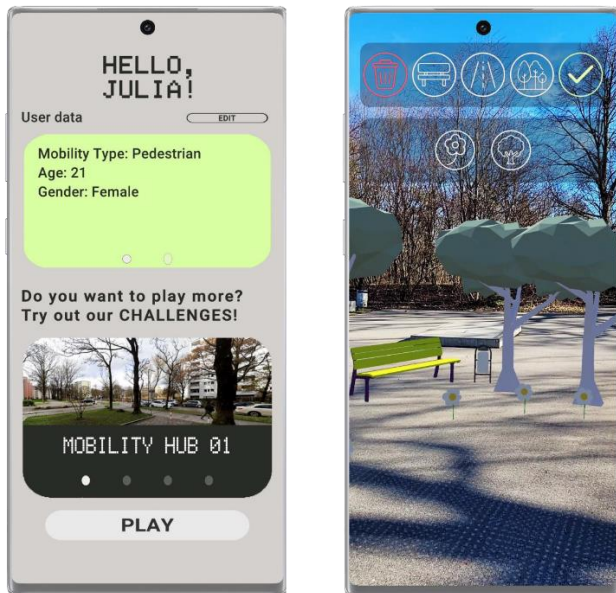
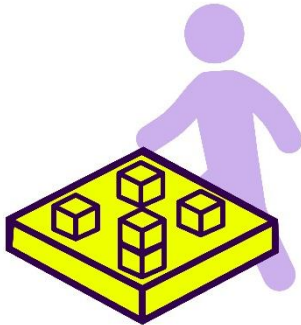


Figure 24 Screenshots ARCanvas. Image Source: prototype team

5.2.8 Cubic Visions



Summary: Cubic Visions provides a building kit of several cubes on a board. Each cube is registered via RFID chips and mirrored on screen with a 3D visualisation, which contributes a playful visualisation to the collaborative interactions with the cubes.

Context of usage: Collaborative workshop

Function: Small-scale localisation, configuration of functions

Key Components: Augmented Reality, GPS Tracking

Team: Carla Sauvant, Chenxuan Ren, Ruilin Dong

Research and Concept: Cubic Visions is a digitally augmented building kit which allows citizens to create new designs for specific urban spaces and discuss different possible functions of a future NEBourhoods Hub. Based on the model-building workshop, the team investigated the potential of tangible interactions in a design context and asked how digital visualisations could support a collaborative design process. The team came up with the concept of a physical building kit of several cubes through which users build and configure their vision for an urban space. The cubes should be recognised by a computer and support the design process by a playful visualisation on a screen (and potentially document different stages of the design process).



Figure 25 Prototype Cubic Visions. Image Source: prototype team

After reviewing different technical approaches, the team implemented the following setup: Each cube contains a UHF-RFID chip registered by an antenna. Combinations of different RFID chips also allow for localising the Cubes on different fields of the table and checking for vicinities between different cubes. A computer recognises the configuration of cubes. This constellation is visualised in a Unity-based app in a playful manner: Each cube has a symbol, and a combination of cubes generates new objects (e.g., two blocks of water make a fountain, a shelter, and a bike make a bike-sharing station). In conclusion, “Cubic Visions” envisions a hybrid building block kit for collaborative workshops. During workshops, participants engage with an urban area, place functions, and discuss ideas. On the screen, the cubes appear as 3D props and animations that interact and merge. This visualisation entices experimentation and discussion of the current setup.

Usage: First, users open the program and move a virtual grid within a digital model of Neuperlach where they would like to place a hub. Then, the user can start to place the cubes on the physical board, and the objects will appear on the screen within a digital perspective rendered in real-time. Also, it is possible to combine two cubes, turning them into a new object using an intrigue crafting system. The cubes can be erased by removing them from the board and clicking on them on the screen.

Resulting Information: The toolkit does not target the generation of a large data set but supports a specific collaboration process. It helps to explore different alternatives together and communicate with other participants. For documentation, the tool can also show several intermediate steps that have emerged during the design discussion.

Link to Github-Repository: <https://gitlab.lrz.de/nebourhoods/cubicvisions>

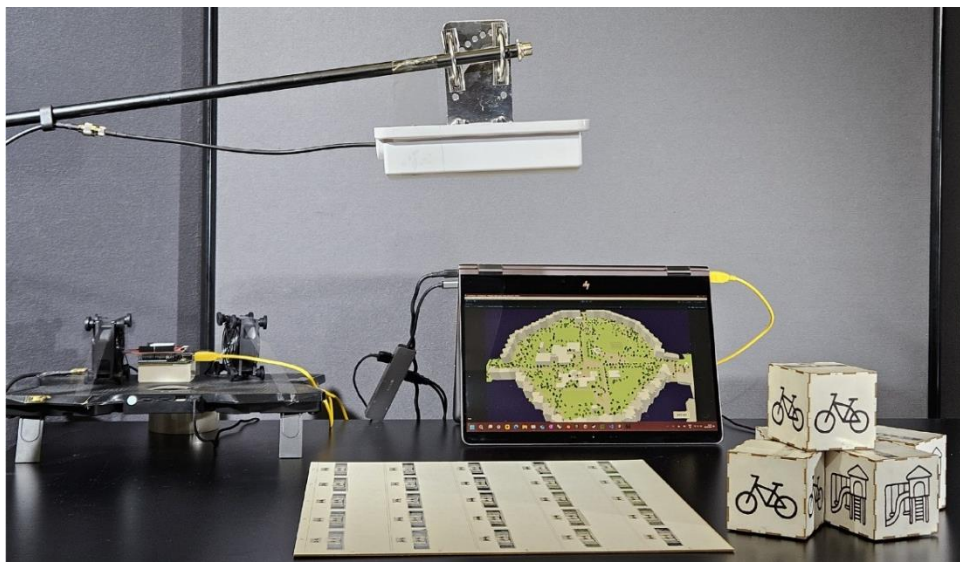


Figure 26 Screen and Toolkit: Cubic Visions. Image Source: prototype team

6 EVALUATION

For an evaluation of the resulting tools, we decided to conduct tests in Neuperlach to understand people's reactions to digital tools in a real-world scenario. The goal was to analyse whether participants preferred one mechanism of participation over another and, most importantly, whether they considered it an effective way to provide participatory feedback.

The event was designed as a full-day session, during which 6 out of 8 prototypes would be available for testing. Yet, at the end of the first day of testing, the number of responses gathered was not satisfactory. Therefore, the test was continued on a second day. Both tests took place between July and August of 2024 at one of the installed NEBourhood Hubs (at Therese-Giese Allee, Neuperlach). This location was chosen due to the tools' connection to the hubs and Neuperlach. On both days, the weather conditions were warm and sunny.

The tested prototypes were CitySwipe, Co-Locate, Mark Your Future, Drifter, GraffiWhere and AR Canvas. The prototypes were chosen according to their practical functionality to provide precise feedback about participatory matters. Additionally, to gather qualitative and quantitative data, photographs were taken, notes were made, and a survey was carried out. The questionnaire was a single form made for surveying all prototypes at once. It included sections on general user information, overall impressions of the digital prototype, interactions with the prototype, inclusivity, and general feedback.

Several students who were members of the teams making the tools assisted with the test, along with four members of the Chair of Architectural Informatics. The testing sessions lasted between 10 and 15 minutes each and consisted of three phases. First, members of the testing team approached people who were passing by and asked if they could participate. Next, they would test the prototypes – the choice of the prototype was left to the testers according to their personal interest. For instance, children were generally more interested in "Mark Your Future," while those more familiar with the topic of urban mobility were directed to "CitySwipe." Lastly, they should answer the questionnaire regarding the prototype they tested.



Figure 27 Test Event at the NEBourhoods Hub at Therese-Giese-Allee. Image Source: NEBourhoods/Nick Förster

6.1 PARTICIPANTS

The participants' demographics consisted of 46 people. 13.6% of the users were between 12 and 18 years old, 50% between 19 and 35, 31.8% between 36 and 67, and 4.6% from 68 onwards. They were distributed into ten testers for AR Canvas, eight testers for CitySwipe, five for Co-Locate, five for Drifter, eight for GraffiWhere, and eight for Mark Your Future. Most participants were residents of Neuperlach, 27,3% were connected to the NEBorhoods project, 11,4% were “others” - included students, workers who were invited to the event, or passersby on the day that were not related to Neuperlach – and 6,8% working or student in Neuperlach.

Overall, the test was well received by the community on both days. Positive comments were left, such as, "Yes, it would be very nice to have a tool like this because the neighbourhood needs attention to improve these matters." However, not all the people approached wanted to test the prototype; some only wanted to talk about the physical NEBourhoods Hub or

claimed not to be familiar enough with digital applications. Many elderly people commented, "Digital things are not for me," or "I am too old for that." This can be even more evident when seeing that, according to the survey, the age group that had the most fun and found the prototypes easy to understand is from 12 – 35 years old.

6.2 LEARNINGS REGARDING INTERACTIONS

The participation tools were developed based on learnings and requirements from the analogue workshops, as we have described in Chapter 3.1. We have analysed these different formats and incorporated specific learnings (chapter 3.2.2) into concepts for different participation tools

The survey should evaluate if these aspects were comprehensible for users and if the learnings from the workshops had a positive impact on the usage of these tools. Therefore, we transformed the six categories of learnings, as introduced in Chapter 3.2.2, into questions for the survey:

Bodily movement:

"If the test included bodily movement, how much was it helpful for exploring the area or gathering ideas?"

Group interactions:

"How could the tested prototype help to develop ideas and collaborate in groups?"

Interactions with the environment:

"Was the experience helpful in getting to know the explored area?"

Mapping:

"If a map was part of the digital prototype: How important was this map in the test?"

Design interactions:

"How well were you able to create your own design using the digital prototype?"

Feelings:

"How well does the tool allow a personal or emotional approach to the discussed matters?"

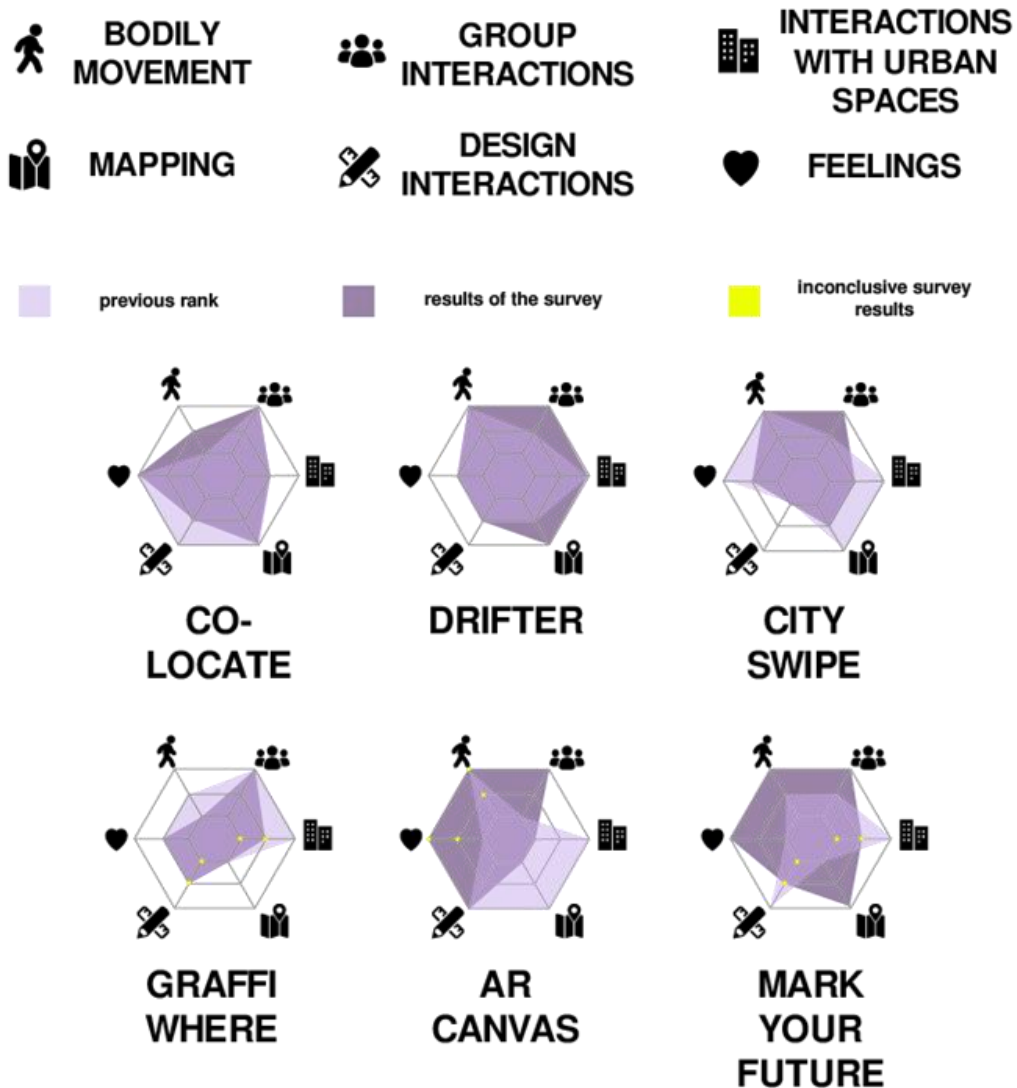


Figure 28 Comparison of how we considered the learnings to impact the user experience vs. feedback from testers

As shown in the figure above, we compare how we estimated the different learnings to impact the user experience of our prototypes against the feedback of our testers. “Previous Evaluation” represents our analysis of the prototype before the testing event, based on the concept and the design intentions. It is possible to see that the prototypes vary from one another. Apart from Interactions with urban spaces, which is ranked 3 (= very high) for five out of the six prototypes, all the other categories have different ratings. “Evaluation after the survey” shows the answers from the survey. It is noticeable that there is a significant difference between some of our design intentions and the testers’ evaluation.



Co-Locate showed differences in the "Bodily Movement" and "Design Interactions" categories. The testers rated "Bodily Movement" higher, which is confusing since most participants did not walk any specific route for testing. They were instructed to rate only the routes they had already taken, leading to the suspicion that they interpreted bodily movement as something required before testing the prototype. On the other hand, the lower rating in "Design Interactions" is understandable, as the interface suffered from some problems, and users seemed unclear about the final task of placing the hub and providing a rating.



Drifter also showed differences in two categories: "Group Interactions" and "Mapping," both of which received higher ratings from testers. The higher rating in "Mapping" is understandable, as users needed to walk a route to test the prototype. However, the higher rating in "Group Interactions" is more perplexing since none of the users interacted with others during the test. It's possible that testers associated the need to consider other roles with the concept of group interactions.



CitySwipe only matched our ratings in "Bodily Movement" and "Design Interactions," with other categories varying significantly. The low rating in "Feelings" makes sense because not all testers were familiar with the area, limiting their ability to express strong feelings. The rating for "Group Interactions" is also understandable, as users could view other people's graphics in the app, though we did not rate it higher due to the lack of live interaction. The lower rating in "Mapping" is reasonable since some users preferred not to walk with the map for long periods, leading to more interaction with the environment and less interaction with the map. Furthermore, the ranking for "Interaction with Urban Spaces" was lower than expected.



GraffiWhere had different lower ratings in both "Bodily Movement" and "Design Interactions," which aligns with the test report. Participants were less willing to move around and tended to draw items that were mostly out of context, explaining the lower scores in these categories. Also, this result highlights the importance of embedding the tools in an appropriate "social format." While short tests with pedestrians led to these results, a longer workshop-based evaluation of GraffiWhere, which was conducted during the prototyping process, led to a much deeper engagement with urban spaces.



AR Canvas only received the same scores in "Bodily Movement" and "Design Interactions"; for all other categories, the responses were entirely different from our previous analysis. "Group interactions" was rated higher, which is

understandable since most of the time, the supervisor of the test had to show how something was done, and, in some moments, users showed the prototype screen with their design to the person who was accompanying them. The rest of the discrepancy could be due to users not having enough time to familiarise themselves with the tool through a pre-test before the actual testing, which may have affected their evaluation.



Mark Your Future showed significant differences across all categories. The lower rating for "Design Interactions" is understandable, as the prototype was set up in a rather sporadic way and had some problems when placing objects in the camera view (e.g. when the light changed drastically). This likely impacted the overall user experience and evaluation. At the same time, it received very high scores for "Feelings", "Bodily Movement", and "Group Interactions" – during the whole testing day, the media column attracted people, and several groups of children played with the tool.

After comparing both perspectives, there is a significant difference between our opinions and those of the users. Obviously, testing a tool for a few minutes gives a different impression from being part of the tool's development process. Since this comparison was a curiosity-driven experiment, it is important to note that there are no right or wrong ratings. The discrepancy does not impede the effective usage of digital tools. At the same time, the results show that it is crucial to introduce participants in more detail about the functionality, the usage and the goals of each tool. Especially in a longer and more effortful format, it would be essential to build a common understanding first.

Digital tools should always be understood in the context – social formats and urban spaces – in which they are used. Explaining the prototypes and helping testers was often interpreted as "Group Interactions." Tools originally conceived for individual usage (e.g., the AR tools) became a collective experience. Other tools – like GraffiWhere – could not unleash their full potential (to generate ideas or explore urban spaces) when used only on a single spot by testers who were not willing to spend a longer time with the prototype.

6.3 GENERAL EVALUATION OF THE PROTOTYPES

In this section, we gathered general feedback about the prototypes. "Expressing opinions" presents responses to the question: "How well did the digital prototype allow you to express your opinion?"; "Develop new idea" covers: "How much did the digital prototype help you develop new ideas?"; "Fun Level" addresses: "How much fun was it to use the prototype?"; "Easy and intuitive" examines: "How easy and intuitive was it to use the digital prototype?". Participants could rate each aspect on a scale from 1 (very low) to 5 (very high).

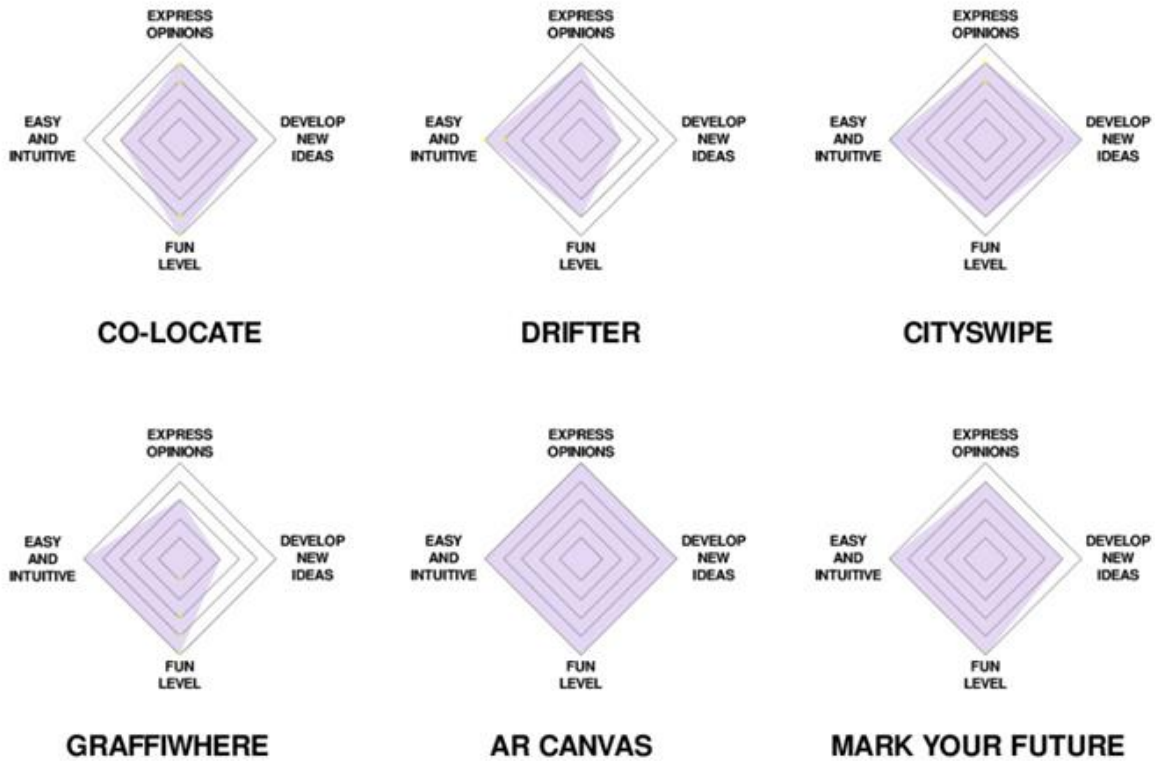


Figure 29 Evaluation of each tool according to user feedback.



Co-Locate was rated between 3 and 5, with the lowest being for “easy and intuitive,” possibly due to the map area used in the prototype being unfamiliar for the testers, which made it harder for some participants.



Drifter achieved very high on most questions, except for “developing new ideas.” This is understandable because the game’s challenge was already predetermined, requiring users only to place a pre-defined object (benches).



CitySwipe scored high across the board, with the lowest scores being a tie between 3 and 4 in the “Expressing Opinions” category. This is surprising given that the app is designed to ask users if they like or dislike a place—perhaps the pre-set categories limit expression.



GraffiWhere scored high on “Easy and Intuitive,” likely due to graffiti being a familiar topic. However, it scored 2 and 3 on “developing new ideas” and “express opinions.” On the one hand, this could be caused by the prototype’s imperfect interface. On the other hand, this impression could be derived from the short and rather superficial interaction with the tool during the test.



AR Canvas got a “very high” on every question, showing strong participant approval. The tool worked well, and the use of Augmented Reality with pre-defined objects on a mobile phone made it more accessible.



Mark Your Future ranged between 4 and 5 on all questions, indicating good acceptance by participants. The tangible interface was intuitive and easy to understand, making it appealing across different age groups, likely due to the minimal “digital barrier” presented by the tangible objects in the game.

In conclusion, based on the survey responses, AR Canvas received the highest ranking for expressing user opinions. The other prototypes scored between 3 and 5. AR Canvas and CitySwipe were rated highest for helping users develop new ideas, while Drifter and GraffiWhere scored below 3. AR Canvas and Mark Your Future were the most fun to use, with GraffiWhere being the only one with scores below 3. The easiest and most intuitive prototypes were AR Canvas, CitySwipe, Mark Your Future, and GraffiWhere. That shows that the best responses were linked to prototypes that use Augmented Reality. Overall, the questionnaire results indicate that participants generally accepted the prototypes well, with the most common rating being “very high” (=5). Of course, the interactions between our team and the testers were generally friendly, which may introduce a positive bias in this evaluation.

6.4 QUALITATIVE ANSWERS

Additionally, the questionnaire included a set of open questions for qualitative analysis.

6.4.1 Contribution to Urban Planning

First, we asked: “In your opinion, how can the tested prototype contribute to urban planning?”. We have sorted the answers according to five topics: **Citizen participation, mobility and transport planning, feedback for urban planners, visualisation, engagement and playful interaction.**

Civic participation stands for allowing people to share their opinions and participate in design decisions, ideally leading to better and more inclusive urban spaces. As one respondent noted, “Residents can give their opinions on various aspects of the places where they live, which can contribute to urban planning.” This topic was quoted in 15 answers, including all prototypes.

Mobility and transport planning suggests that integrating user input can improve infrastructure and transportation solutions. “For the mobility of people, it would be useful to support better ways or feedback where to improve the infrastructure.” This topic showed up in two answers from Co-Locate testers.

Feedback for urban planners indicated that collecting and analysing feedback can provide insights into areas such as safety, accessibility, and general satisfaction. “When many people place messages to the same aspect as safety or fun, this should say something to the planners.” This highlights feedback that can help planners address common concerns and prioritise improvements. This showed up in three answers, all of them CitySwipe testers.

Visualisation in urban planning helps to discuss changes, support the creation of new designs, and provide understanding for refining urban spaces. As one response stated, “Allows to sketch and change places into a more ideal version of it.” This aspect was notably supported by prototypes utilising Augmented Reality, such as GraffiWhere, Mark Your Future, and AR Canvas.

Engagement and playful interaction were discussed in terms of making urban planning more enjoyable. “It can contribute to making people understand how it is to walk without being in your own character role.” This reflects the potential of using gamified elements and playful interactions to encourage participation and gather diverse perspectives on urban spaces. This topic showed up in four answers in feedback for Drifter, AR Canvas and GraffiWhere users.

6.4.2 Missing Features

To learn about possible improvements to the applications, we asked the testers: “What features do you think are still missing to improve the experience?” We divided the feedback into two groups: “**More Feedback Tools**” and “**Usability**.”

More feedback tools were a topic in several responses from all prototypes. Suggestions included adding more options for user comments and interaction. For instance, one respondent suggested, “A space to write comments.” Another tester noted the need for “More space to write down the comments in the end.” Improvements were also proposed for the commenting interface, such as “Maybe option to comment on another picture than the one given” and “Adding a written note.” Other feedback included the desire for better visualisation aids like “Maybe some picture or a map with better visualisation for people who do not read a map easily.”

Usability was another key area of focus for all prototypes, with suggestions aimed at improving the overall user experience. For example, one answer pointed out that “Some buttons lack captions explaining what the buttons do, for example, if you want to write a comment.” There were also requests for better spatial and interface enhancements, such as “Easier implementation without building blocks. Better spatial implementation with the use of other cameras...” and “Maybe improve a little the interface in order to make it possible to edit things from a greater distance.” Additionally, some feedback included improving specific

features that were not fully working on the prototype, like “The 'spray function' is very difficult to use” and “The drawing tools can still improve and maybe allow to take a picture and then after draw on it.”

6.4.3 Accessibility

The third question was: “How could the prototype become more accessible for you?”. We sorted the answers according to the following categories: User experience, target groups, and **community use**.

Users experience related answers targeted at making the prototype more user-friendly and adaptable to different devices. They included improving some mechanisms and interaction methods. For example, “Optimized for mobile devices.” reflects the need for better mobile integration, while “Voice control (LLM)” and “Recognition voice messages for comment” highlight advancements in accessibility through voice technology. Additionally, improvements in interface design, such as “Labels in the main menu” and “Better menu navigation,” are seen as essential for a smoother user experience. This topic appeared in 13 answers, which included all prototypes.

Target groups include the prototype's appeal to younger audiences. “I rarely use my cell phone. This is more interesting for young people.” suggests that the design may need to be tailored to engage users who are less familiar with technology or have different device preferences. The answer was given by a Mark Your Future user, although, during the test day, we got a lot of those comments regarding all prototypes.

Community use focuses on enhancing the collaborative and shared aspects of the prototype. Suggested enhancements included making the platform more open and interactive among users. For instance, “It could be more open and shared with other people.” and “If you had access to the map where you could see other people's drawings.” Additionally, “As an app/game perhaps also accessible at school or in a workshop.” suggests extending the prototype's use to educational and communal settings. This topic was brought up by Cityswipe, Graffiwhere and AR-Canvas testers.

6.4.4 General Feedback on the Testing Process

The final open question aimed to gather feedback on the test event, and while responses were generally positive, with comments like “very good” and “very helpful,” there were also specific suggestions for improvement. Three responses provided valuable insights into how the event could be made more effective. The primary feedback highlighted the need for greater visibility, with suggestions such as “More visibility” and “It's nice to be able to try out lots of things. A poster, beach flag or something similar would be good for better visibility.” Another respondent noted, “Bigger poster to attract attention, I didn't see anything was

happening.” This feedback indicates that improving the visibility of the test day could help ensure it is more easily recognised and attended by passersby.

6.5 DISCUSSION

The survey, as well as the practical experience testing process, highlight some points regarding the participation tools. Especially the tests showed that it is important to understand digital tools in a concrete context with respect to social and spatial aspects. Furthermore, it highlighted the importance of understanding the whole process of creating prototypes as a co-creative activity (and not just the deployment of digital tools). Moreover, we gained some critical reflections on our tools.

Firstly, testing showed that social formats of co-creation and digital tools have to be designed and planned together. Tools like AR-Canvas required an introduction, and users who were not familiar with digital tools needed personal support. As the survey shows, some users even understood the usage of the apps as a collaborative activity. Other tools – like GraffiWhere – could not realise their full potential since they were tested in the wrong conditions. Also, elderly users who first claimed not to be used to digital media could participate with support from our team. This highlights that the usage of digital tools must go hand in hand with analogue co-creative approaches.

Furthermore, the usage of tools was influenced by the spatial and material configuration of the test event. While some testers wished for a poster to enhance the visibility of the tools, the prototype “Mark Your Future” benefited from its large interactive screen and large tangible markers. During the test event, the tool attracted pedestrians and appeared more attractive than the mobile phone-based apps.

Several testers addressed imperfect user interfaces and functions, which were not fully implemented (e.g., for not implemented multi-player functions in city swipe). This confused several users. For future development, we suggest developing the tools in a more “minimalistic” way. Only central functions (e.g., the main interaction – like placing objects in AR – and the possibility of data saving) should be implemented. At the same time, additional functionalities can be covered by additional analogue instructions and materials (like the paper manuals, which were part of the prototypes). In this way, adapting tools in the process is also more realistic.

Lastly, our evaluation highlighted the potential to approach not only the deployment of digital tools but also the making of tools as a co-creative activity. The test showed that some groups (especially elderly persons) were often not interested or able to use digital tools. This effect could only be partly compensated by supporting them. This shows the importance of including these perspectives also in other ways. For instance, the “Drifter” prototype started with an analogue interview phase to configure the prototypes. Other tools that involve a

library of mobility-related items should be configured in collaboration with stakeholders as well. Also, considering gender dimensions, the co-creative configuration of the tools is crucial. While gender aspects were not addressed directly in the survey's answers, they were an important topic for the design and prototyping of the tools. For instance, "Drifter" included research and a mini-game concerning the safety of public spaces for female persons. Related aspects of safety and accessibility aspects were addressed through specific challenges in the tools "AR Canvas" or "GraffiWhere". Learning from the co-creation formats with citizens formed a basis for investigating such situated problems. Engaging with the Drifting workshop also led to the "Co-Locate" tool, highlighting the perspectives of people experiencing mobility impairments. Thus, we aimed to include these aspects in the prototyping process by building upon the co-creation formats, staying in exchange with creatives and testing the tools with citizens of Neuperlach. This aspect could also be developed further in the future, experimenting with deeper ways of including residents and local stakeholders in the prototyping process.

7 CONCLUSION AND OUTLOOK

With this report, we have documented the prototyping and implementation of a digital platform consisting of several digital tools for cooperation and participation. Firstly, we have outlined the importance of situating digital tools with respect to a concrete urban context. Therefore, we have introduced our vision of a platform – consisting of a technological foundation and several digital tools. The foundational modules provide data from the digital twin as well as innovative media and interactions for the prototyping of participation tools. In this way, the tools can be adapted to concrete tasks and situated aspects of participation and planning processes. For instance, the prototype “GraffitiWhere” incorporates learnings about graffiti subculture in Neuperlach into a participatory format. “Drifter” and “Co-Locate” aim at highlighting marginalised mobility experiences – such as the perspectives of elderly persons, wheel-chair users, or the safety of female citizens. Lastly, we have tested and evaluated the emerging toolbox in Neuperlach.

The documented process corresponds strongly with the principles of the New European Bauhaus. Firstly, “design” and an aesthetic experience were central to the action. The documented participation tools aim to enhance aesthetic value by including citizens in the co-creation and design of NEBourhood Hubs and surrounding public spaces. Thus, the toolbox supports the creation of attractive and comfortable spaces. At the same time, the aesthetic experience of co-creating is crucial. We collaborated with several creatives to develop innovative and beautiful experiences of exploring urban spaces and discovering new perspectives. In the context of digital tools, these aesthetic aspects are combined with experimental media like Mixed Reality. The resulting prototypes opened up new aesthetic experiences, e.g., through a combination of corporeal investigation and interaction with urban data. Other tools use new digital media to allow citizens to collectively envision future urban spaces and innovative mobility.

Furthermore, the action also contributes to how we design and inhabit urban spaces together. Both co-creation formats and digital tools highlight experimental forms of co-creation and involve different stakeholders. Thus, the process offered opportunities for encounters and new discoveries. The project builds upon the interdisciplinary exchange between citizens, planners, artists, computer scientists, and municipal institutions.

Digital technologies are not to be understood as abstract solutions but depend on concrete social formats, collective experiences, and collaborative workshops. The prototypes bring new technologies (e.g., data from the Digital Twin) together with the situated experiences of citizens (e.g., discussing the lighting of public spaces to feel safe at night or improving urban furniture to make public spaces more accessible for elderly persons). With respect to the accessibility of digital tools, we show diverse ways how to include different groups’ perspectives into the toolkit – from configuring tools through oral interviews to collaborating

with haptic and intuitive interfaces. Deploying digital tools involves social interaction and requires helping users and caring for each other.

With respect to sustainability and the transformation of mobility, we developed a valuable toolbox for future projects. As we have argued earlier, mobility is a wicked problem linked to various stakeholders' experiences, the aesthetics of urban spaces, and complex everyday practices. Including bottom-up perspectives in planning processes is crucial to finding truly sustainable and innovative solutions. At the same time, our approach involves new technological possibilities from Digital City Twin projects. As many cities in the European Union foster similar projects, approaches to combining urban data with co-creation approaches could be valuable resources for sustainable urban planning.

On the one hand, the action Mobility NEBOurhoods provides a toolbox for the co-creation of mobility-related infrastructure and public spaces. This toolbox emerges from concrete formats and learnings from Neuperlach and the NEBOurhoods project. On the other hand, the shown process demonstrates a productive relationship between the co-creation formats with various stakeholders (citizens, planners, artists, municipal institutions, etc.) and the collaborative prototyping of participation tools. Making digital tools together to highlight the perspectives of different stakeholders and to learn about mobility appears as an innovative approach that could be combined with participatory methods like “Critical Making” (Ratto, 2011), “Data Feminism” (D’Ignazio & Klein, 2020), and “Critical Mapping” (Crampton & Krygier, 2018). In this way, the presented tools and methods could become crucial for future planning projects, like the implementation of mobility hubs or adaptations with respect to climate change.

Currently, we are discussing the future usage and further development of the presented toolkit together with the Smart City Strategy team (ISCH core team) of the City of Munich. Together with this cross-departmental group in the city administration, we elaborate on how results from the action “NEBOurhoods Mobility” will further contribute to participatory planning projects. In the NEBOurhoods replication handbook, we outline how different aspects of the described process can be reused – learning and experimenting with analogue formats, collaboratively assembling, and configuring digital prototypes, and including these prototypes in social formats (see NEBOurhoods for Tomorrow, www.nebourhoods.de/results) . In doing so, we have identified a set of useful tools, resources, and approaches that can form a basis for future work at the Chair of Architectural Informatics and which can be used by other actors – in Munich and beyond.

8 TECHNICAL ANNEXE

In this annexe, we describe the development of several technological modules mentioned in Chapter 4 in more detail. The basic problem was that we were provided various sets of geo-data from the city's Digital Twin project, which we wanted to combine into easy-to-use components. The developed technical foundation should make it possible to develop various digital prototypes based on these data sets. The requirements can be summarised as follows:

- Digital modules that enable others to build on it
- Easy use of the various available data sets
- Visualisation and interaction primarily in 3D

The developed code can be accessed via Gitlab:

<https://gitlab.lrz.de/nebourhoods>

8.1 GAME ENGINES AS EXTENSIBLE TOOLBOX

Given the requirements, the initial decision was quickly made to use a game engine as the basis. An alternative to this would have been to use a web application with three.js as the basis, for example. The biggest disadvantage of this was the cumbersome use for non-developers, which would have significantly increased the familiarisation time. Other frameworks, such as Flutter, could have helped out here but were not particularly suitable for 3D worlds. Among the game engines, there were three in particular that came into question: Godot, Unity and Unreal Engine. We ruled out the latter from the outset, as its hardware requirements are quite high and would therefore not have been appropriate for all prototypes. Furthermore, the Unreal Engine is probably a little more difficult to learn, not least because Unity's community is larger and Unreal is based on C++ instead of C# like Unity. The latter programming language is generally considered easier by programming beginners. In comparison between Godot and Unity, Unity has a larger community, as already mentioned. This means, among other things, that any problems that arise have a higher probability of finding a corresponding tutorial that solves them. In addition, Unity has been on the market for longer, and its user-friendliness is somewhat more advanced.

Based on these considerations, we finally decided in favour of Unity. This engine offered us a beginner-friendly user environment that made it possible to create interactive 3D prototypes with relatively little programming knowledge. 2D prototypes are also possible if desired. The prototypes can be used on various end devices. One problem that Unity had was that it was somewhat more difficult to connect with the semantic data than would be the case with other software projects, for example. This is because although Unity uses C# as its programming language, C# libraries are not readily applicable. Nevertheless, there are so-called plugins

that have a similar function to libraries. Using Cesium¹² (a Unity plugin) and BlenderGIS¹³ (another tool), we were able to get the whole thing up and running. More on this in the corresponding chapters.

8.2 MODULAR GEO-FUNCTIONALITIES

As already mentioned, the entire project is based on Unity. The digital twin part of the project then came from our side. This consists of three basic parts: the underlying data set of the city, the 3D model that largely results from it, and a digital twin service. The latter is a service that we provide to simplify accessing and analysing the data set. As can be seen in the graphic, the 3D model is transferred to the part of the project where the actual prototype is created. The end result should be precisely this participatory prototype that is developed in the prototyping process. We wanted to provide the makers with the best possible tools and data that they need for this. As we cannot completely anticipate the final 3D model, we created it in such a way that it is completely part of the digital twin on the one hand - but on the other hand it can be extended for the respective final use case.

The final prototype can also rely entirely on Unity and is not solely dependent on the Digital Twin for its functionality. This is particularly useful and this is where the whole advantage of Unity comes to the fore. As the Digital Twin now works together with Unity, the tool-makers can utilise the full range of Unity's functionality. This means they can develop applications for different devices, e.g. web, desktop, VR, AR, etc. They can also access a lot of freely available documentation and tutorials on the internet. These do not help with our Digital Twin, but as this is only one part of the whole, it is still very useful.

A special feature of Unity as a basis is that GIS data cannot be used without further ado. Many GIS tools are based on browser-based visualisations (e.g. Mapbox, MapLibre, Leaflet, OpenTiles, etc.) and/or require special libraries and tools, such as GDAL/OGR¹⁴. Since Unity uses C#, but is not based on .NET, GDAL integration was not trivially possible. However, a tool such as GDAL is very useful for reading in various geodata (such as shapefiles, GeoJSON, etc.). Other tools such as PROJ¹⁵ help to merge different coordinate systems. One thing we wanted to make possible, for example, is for a player to be able to move around in our Digital Twin and find out their world coordinates (longitude and latitude) in real time. Unfortunately, this is not easily possible in Unity. The best solution for Unity is probably Cesium¹⁶, which is what we finally decided on. With Cesium we were able to achieve exactly

¹² CesiumGS, Cesium for Unity Samples, <https://github.com/CesiumGS/cesium-unity-samples/releases/tag/v1.15.4>

¹³ Domlysz, GitHub Respository, *Blender GIS*, <https://github.com/domlysz/BlenderGIS>

¹⁴ ViRGIS, GitHub Repository, <https://github.com/ViRGIS-Team/gdal-upm>

¹⁵ Proj Contributors, *Proj Library Documentation*, <https://proj.org/en/stable/about.html>

¹⁶ Cesium works as a AR geospatial cloud anchor to store digital data in the real world

that. Cesium itself also had other advantages, for example that it made it easier for us to load our geodata into our world.

Specifically, in addition to the basic digital twin, we wanted to provide some basic building blocks on which the prototypes could build upon. We discussed some essential functions that the prototypes would require:

- Geolocate objects in the 'real' world as well as in the 'Unity' world
- Read GeoJSON files
- Query metadata about objects
- Find nearby objects starting from a coordinate

8.2.1 Geo-localisation of Objects

We wanted prototypes to be able to easily geo-localise objects in the Unity world. The whole thing is not trivial, as we are basically dealing with two different coordinate systems. On the one hand, we have the Unity coordinate system. Unity is based on a 3D world where every object or point has an (x,y,z) coordinate. This starts at a (0,0,0) point, which Unity specifies. A Unity world can then be created based on this. Converting these into longitude and latitude, as we do in the real world, is anything but trivial. As previously mentioned, we, therefore, use the Cesium plugin to help us out here. Cesium allows us to do exactly that: starting from a Unity coordinate, we can query its world coordinates and vice versa.

Objects can now be placed according to their unity or world coordinates. It makes sense to place them according to their unity coordinates if they are to be placed 'by eye'. However, if they have to be placed at a very specific position in the real world and you only know the world coordinates of this position, this is now also easily possible. This can be seen in the image on the right: At the top under 'Transform' you will find the Unity coordinates of an object. Further down, in the 'Cesium Globe Anchor' box, the corresponding coordinates are converted into world coordinates (longitude, latitude and altitude).

8.2.2 Importing Geo-JSON files

Geodata is often available in various file formats. Alongside shapefiles, GeoJSON¹⁷ is probably the most common format. We wanted the tool-makers to be able to load these geodata and make the data usable in their prototype. For example, the tool-makers may have a file of tree data for the neighbourhood that geo-localises trees. One use case for this data set could be to place the data in the Unity world in a realistic way. In addition to geo-localisation (see previous section), it must be possible to read in the data. Shapefiles are less suitable for this, in contrast to JSON files. Our idea was, therefore, to provide auxiliary methods that can read GeoJSON files. What then happens with the imported data is at the

Cesium GS, Inc., *Cesium for Unity*, <https://cesium.com/platform/cesium-for-unity/>

¹⁷ Mapbox and OpenStreetMap, *GeoJSON*, <https://geojson.io/#map=2/0/20>

discretion of the user of this method. If the data is only available as shapefiles (or other geo-file formats), we recommend first converting it into GeoJSON using open tools such as QGIS.

8.2.3 Querying Metadata for Objects

To stay with the example of tree data: These can not only be geo-localised but also contain metadata on the respective trees, such as the height of the tree or tree species. We also created helper methods to simplify this. The picture shows the whole thing in practice, whereby a raycast is used to capture the building that the user is currently pointing at. We then retrieve the metadata of the building that we currently have in this data set, and in this case we simply display it in a pop-up window.

8.2.4 Finding Nearby Objects

We also wanted to make it possible to find nearby objects. Our idea here was that this might be good for finding places with lots of trees in the neighbourhood, for example. Unity already gives us most of what we need with the `OverlapSphere` method¹⁸. We then created an example code for the prototyping process. The image shows trees in the environment for visualisation purposes. We have coloured trees that are within a set radius (50 m in the image) black. This is to clearly visualise which trees would be affected and which would not.

8.3 ADDITIONAL ASSETS AND FUNCTIONALITIES

In addition to the geo-functionalities which were developed, the foundational toolbox consisted of a range of resources aiming at making different promising functionalities available in the prototyping process. The decision to rely on a Game Engine like Unity offered the great advantage that User interactions, GPS-tracking, camera access on mobile devices or Augmented Reality and Mixed Reality functions are already available as packages or instructions online¹⁹. Still, for a co-creative prototyping process, these resources had to be gathered. Partly it was necessary to create custom tutorials and resource collections. Additionally, a foundational set of assets was created to create a kit of 3D objects, which many prototypes may need (e.g. trees, bikes, a repair station, benches).

8.4 INTEGRATION IN THE CO-CREATIVE MAKING OF DIGITAL TOOLS

Transferring the modules and code developed by computer science team members for the prototyping process, which should rather focus on playing with interactions and playing with

¹⁸ Unity Technologies, *Physics.OverlapSphere*,

<https://docs.unity3d.com/6000.0/Documentation/ScriptReference/Physics.OverlapSphere.html>

¹⁹ Unity Technologies, XR packages, <https://docs.unity3d.com/6000.0/Documentation/Manual/xr-support-packages.html#:~:text=Feature%20and%20tool%20support%20packages%3A%20These%20packages%20provide,by%20installing%20and%20enabling%20the%20relevant%20XR%20plug-in.>

the planning process, was another challenge. We then presented our findings, helper methods and general approaches to students in a workshop lasting several hours. In the workshop, we explained the above as well as how to work with GIS tools in general, especially QGIS²⁰. We also provided a Unity project template, which we used as a template for the workshop itself, but which we hoped would also be a useful 'starter kit' on which effective prototypes could then be built.

²⁰ QGIS, <https://qgis.org/project/overview/>

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