Co-Designing and Mapping for Accessible Cities: A Cross-Disability Project in Zwolle, The Netherlands

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Abstract. Digital collaborative mapping tools are developed for engaging stakeholders in urban planning processes addressing societal challenges such as climate change adaptation, energy transition, or healthy urban living. Existing tools and approaches, such as PGIS, PSS or serious gaming, hold the promise of broad and diverse stakeholder participation in planning-related activities. However, they do not yet accommodate the participation of people with diverse abilities and disabilities, although inclusive participation is called for in international policies and conventions. The paper reports on the development of an inclusive collaborative mapping tool that facilitates the participation of people with disabilities. To this end, we conducted a tool co-design process with a group of people with various physical disabilities in a Dutch case study on accessibility to public space. The envisioned purpose of the tool is to support the inclusive design of urban public spaces that meet the requirements of all people, with and without disabilities. The result is an open-source prototype of an inclusive collaborative mapping tool implemented on a maptable.

Keywords: collaborative mapping, people with disabilities, accessible city, inclusion, co-design

1 Introduction

Digital participatory and collaborative mapping tools are developed for engaging stakeholders in urban planning-related activities addressing societal challenges such as climate change adaptation, energy transition, or healthy urban living. Tools developed in recent years hold the promise of broadening and diversifying stakeholder participation. For instance, maptable-based planning support systems (PSS) (Flacke et al. 2020) aim to support stakeholder participation on a level playing field and overcome power relations that often hamper fair and equal participation. Serious gaming approaches are meant to make participation in collaborative planning tasks more intuitive and playful, thereby diversifying stakeholders' involvement (Poplin 2014). Crowdsourcing data collection using Public Participatory GIS tools (PPGIS) (Nummi 2018) is seen to broaden the database of urban planning and to include local knowledge in planning and decision-making (Pfeffer et al. 2013). Finally, co-designing approaches to collaboratively develop geospatial tools are implemented to overcome issues of usability and usefulness (Pelzer 2017) and to bridge the tool implementation gap (Geertman 2017).

Although inclusive participation is called for in international policies and conventions such as the Sustainable Development Goals (SDGs) and the Convention on the Rights of Persons with Disabilities, (CRPD), none of the aforementioned tools and related studies support explicitly the participation of people with disabilities (PwD). Digital mapping tools are typically designed for average-abled stakeholders, while people with disabilities might not be able to view or access the content of the tool because of limited contrast of the graphical user interface, the lack of auditive support or hardware limitations. For example, tools specifically designed for maptables, i.e. a large-scale tablet interface with geospatial mapping functionality lying flat on a table (Flacke et al. 2020), might not be accessible from a wheelchair or lack suitable interaction modes for visually impaired users (Henning et al. 2017). Such forms of digital exclusion, described in the literature as the digital divide (Egard and Hansson 2021), received attention in various scholarly fields, among which are design studies and disability studies. They offer concepts and guidelines for inclusive design which are to be incorporated into the design and development of digital mapping tools for planning-related activities. The universal design principles (https://universaldesign.ie) postulate the design of tools to make them accessible, understandable and usable to the greatest extent possible by all people regardless of their age, size, ability or disability. The cross-disability perspective (Drainoni et al. 2006) postulates taking the diversity of people with disabilities and their diverse types and levels of capabilities and limitations into account.

In order to address this postulation, this study aims to develop an inclusive collaborative mapping tool for maptables that facilitates the participation of people with disabilities in collaborative planning-related activities. The tool development focuses on the accessibility to public spaces and the inclusive design of urban public spaces that meet the requirements of all people, with and without disabilities. The overall result of the study is an open-source prototype of an inclusive collaborative mapping tool implemented on a maptable, specific for the respective context of use but sufficiently generic to be adapted to other contexts. This paper mainly reports on the following questions: What does access to public space mean? What are relevant user requirements to map access to public space from a cross-disability perspective? What are relevant software and hardware features and characteristics of an inclusive mapping tool to accommodate the diverse disabilities?

2 Background

The urban space is a place of intersecting struggles and opportunities. Accessing services and infrastructure in the public space, such as sidewalks, parking spaces, playgrounds, parks, and important social and medical destinations is essential when living in urban areas. Particularly at the neighbourhood level, non-motorized transport is central to human well-being and sustainable development. However, the extent to which the planning, design and management of the urban space support non-motorized mobility and accessibility at the neighbourhood level do not account for the diverse ways people experience urban space and what their diverse requirements are. Stafford (2022) highlights that cities are often designed according to the image of an able-bodied person

resulting in spaces that are physically or socially not accessible to people with disabilities, defined by Butler and Bowlby (1997, p.411) as "the disadvantage or restriction of activity caused by the contemporary social organization which takes little to no account of people who have impairments and thus excludes them from mainstream social activities." Along the same line, a recent review of 69 scientific papers found that disabilities are hardly taken into account in studies of walkability of neighbourhoods (Stafford and Baldwin 2018).

Disability is produced through the relationship between bodies and their social, physical, and political environment (Terashima and Clark 2021). This perspective, also referred to as the 'social model' of disability, places bodies within space and focuses on the embodied experiences and capacities of people with diverse impairments (Hansen & Philo, 2007). This is helpful in thinking about processes of inclusion and exclusion in both cities and digital technologies. The social model of disabilities also helps understand the relationship between different abled bodies and digital technologies. As Egard and Hansson (2021) note, the increased use of digital technologies creates both beneficial and disadvantageous outcomes for people with disabilities. On the one hand, digital technologies allow for a more seamless integration of diverse user needs. They make it possible to integrate multiple functionalities such as speech operation, zooming, and transcriptions into one technology, such as a mobile phone. On the other hand, due to the lack of inclusive design, people with disabilities are often excluded from the use of digital technologies, creating new disabling conditions and increasing the divide between people at multiple intersections (Egard and Hansson 2021).

A few recent studies designed collaborative mapping tools on the issues of accessibility of public space and the walkability of neighbourhoods. Boulange et al. (2018) develop a Walkability Planning Support System that "enables urban planners to explore built environment scenarios and visualise their potential impacts on walkability". Piazza and Viera (2017) developed a GIS tool to spatialize the walking index in the studied neighbourhoods to support the decision-making process related to urban mobility. Also, the co-design of mapping tools is becoming state of art nowadays (see e.g. Rittenbruch et al. 2021, Aguilar et al. 2021, Prestby et al. 2023). However, none of these studies focuses explicitly on the inclusion of people with disabilities.

3 Methodology

In order to develop an inclusive collaborative mapping tool for maptables, the study employed an inter- and transdisciplinary team-science approach and various methods of data collection, analysis and tool development. In the following, we report on the research team composition, the design of the research and the methods used.

The research team conducting this study consists of three groups: 1) the scientific researchers with a background in urban planning, geography, technology development and disability studies; 2) as co-researchers a group of people with disabilities who are experts-by-experience in the City of Zwolle, the Netherlands; 3) a company specialized in developing geospatial software applications and tools. The coordinating team includes the scientific researchers, a representative from a network for people with disabilities, and a representative of a local organization advocating for people with disabilities in the city of Zwolle. The coordinating team takes care of the practical coordination of the co-design/collaborative sessions, documenting the process, translating the insights from the collaborative sessions to features of the tool to be developed, tool development, and reporting on the project through academic outputs.

The co-researchers consist of various people (in total eight) with diverse mobility and sensory impairments (wheelchair users and sight or hearing impairment) living in the city of Zwolle, Netherlands, and its surroundings. In addition, depending on the group composition, a sign language interpreter was present at the co-design sessions. The responsibility of the co-researchers is to identify the main issues of mobility within and access to public space, share their insights, critically test the tool prototype, and provide feedback on the documentation and reporting of the project. Several members of the experts-by-experience team had already experience in observing the accessibility to public facilities for people with disabilities because they are members of a team conducting regular accessibility audits for the city of Zwolle (https://www.toegankelijkzwolle.nl/diensten/schouwen/). The division in tasks was partly informed by different needs within the project as well as abilities and time availability. The experts-by-experience all participated on a voluntary basis.

The overall methodology of the study was divided into four phases (Table 1). In this paper, we mainly report on the co-design process and outcomes of the first and second phases and the beginning of the third phase, because the project is still ongoing.

Table 1. Overview of research phases and methods applied

1. Preparations and developing co-design approach	2. Identification user needs, tool conceptualisation	3. Iterative tool development	4. Application and evaluation of tool
Ethics approval, data management plan, review of potential methods	Workshop 2: co-design of fieldwork	Tool development Sprints with software developer	Application of tool with co-researchers and city planners/policy makers of Zwolle
Workshop 1: kick-off and co-design methodology development	Workshop 3: in-situ data collection (tour in Zwolle) applying photovoice and geo-narratives methods Workshop 4: collaborative analysis of photographs and lived experiences to elicit user requirements for the tool	Workshop 5: Tool testing with co-researchers	Evaluation by means of a semi-structured survey and open review of the tool

Key element of the first phase was the first co-design workshop aiming to make the teams of researchers and co-researchers acquainted with each other, establish roles and define the methodological approach. The co-researchers provided input regarding how to define the accessible city, how we can capture this, and how we should structure the co-design process. The maptable was introduced and used to discuss spatial aspects of the case study area.

The second phase consisted of three co-design workshops aimed at eliciting user requirements for the inclusive mapping tool. Workshop 2 was used to jointly define the accessible city, determine the goal of the tool, and plan the fieldwork tour to capture aspects of inclusive accessibility from the co-researchers' point of view. The tour (workshop 3) was done in the city centre of Zwolle applying photovoice (Annang et al. 2016.) and geo-narratives (Kwan and Ding 2008) methods, resulting in a collection of photos with descriptions illustrating good and poor examples of accessible planning and design in the city centre of Zwolle. In workshop 4 the photos and geo-narratives from the fieldwork tour were discussed and categorized as mapping features for the tool. The maptable tool was used to explore the geocoded photographs and collect feedback on how to integrate photographs in the maptable tool.

The third phase foresees three sprints of six weeks to develop and test the tool iteratively together with the co-researchers. The basis of the tool development is done in a collaborative mapping and decision-making platform for maptables, developed by the lead scientific partner in earlier projects (Aguilar et al. 2021).

4 First results

In defining what the accessible city (toegankelijke stad) means, the co-researchers elicited several important insights. First of all, the accessible city refers to the proactive creation of choice of opportunities for all urban residents irrespective of their (dis)abilities. The term proactive is important in this definition as it points towards the responsibility of the municipality and state to take the lead in creating an inclusive city. Secondly, it was added that the accessible city means that both physical and social space are made accessible. Hence, it is important to remove both physical and social barriers limiting people with diverse disabilities to participate in urban life in ways they see fit. This is in line with Brants et al. (2017) who state that in the Netherlands public policy addressing disability and inclusion has resulted in a segregated system in which people with disabilities live separate from the rest of society.

During the fieldwork tour, several issues limiting access to public space for people with disabilities in the city of Zwolle were documented (see figures 1, 2).

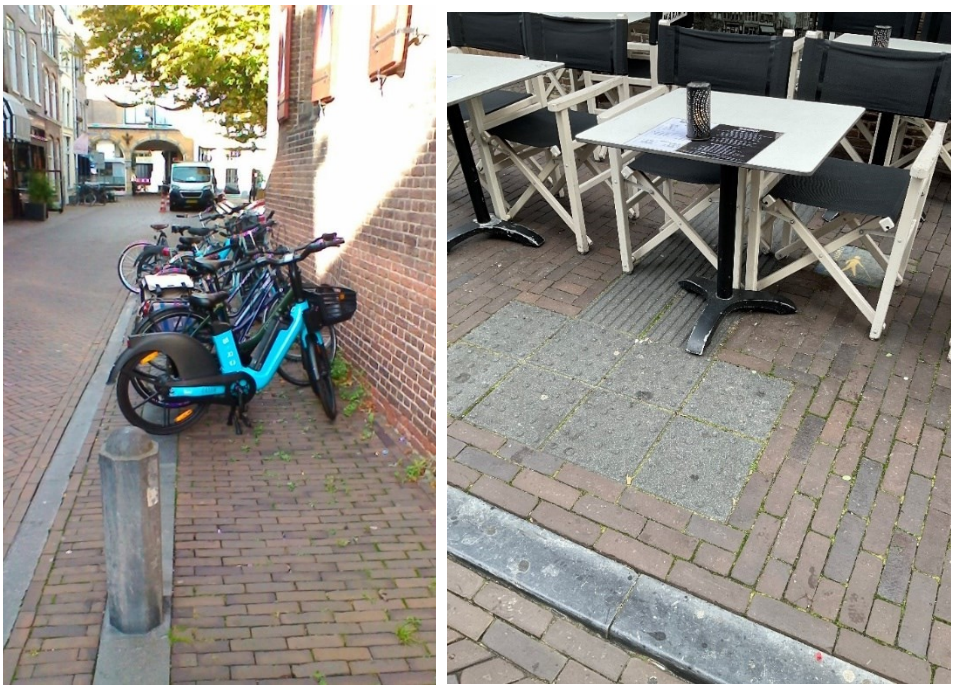

Fig. 1. 2 Examples of limiting access to public space for people with disabilities. Left: a street with a single-level roadway and sidewalk. A sunken curb and row of bollards demarcate the roadway from the sidewalk. The pedestrian zone is blocked by parked (electric) bicycles. Right: a sidewalk with tactile paving indicating a crossing point before a sunken curb. The tactile pavement is blocked by chairs and tables of a nearby restaurant. (Sources: authors)

Limitations of accessibility to public space detected during fieldwork were classified into the categories shown in Table 2.

Table 2. Categorization of issues with regard to access to public space

Category	Description / variables
Traffic design	Can be illogical/counter-intuitive, or unsafe; e.g. ramps that are not aligned or the removement of traffic lights (or turning off the ticker at certain times of the day, e.g. past 8 pm) which makes it more difficult and dangerous for people with disabilities to cross the street.
Ramps	The most important issues are placement and shape. Is the angle right? Is the placement logical? Are they well-designed? Are the 'signs' related to the ramp well positioned?
Pavement	Needs to have a smooth and consistent surface; for people using a guidance stick, each bump means they get a shock to their shoulder. For people in wheelchairs, an uneven pavement can be uncomfortable. For people with a rollator, an uneven surface/loose pavement can hinder them in their movement; aesthetic lines may get slippery when wet.
Guidelines	Guidelines have to be consistent, integrated with natural guidelines, and accessible/visible; often guidelines are not integrated well making people lose track, are blocked by obstacles, or are simply missing; a bench if close to the wall/railing can serve as support.
Obstacles	Can be fixed and permanent (lanterns, signposts, benches) or mobile and temporal (bikes, scooters, scaffolding, chairs and tables on terraces, construction work); permanent and temporal obstacles have to be minimized; for temporal obstacles such as construction work, it is important that people are informed and can plan alternative routes.
Public transport	Difference in accessibility on paper and in practice. Do the bus drivers have a mobile ramp and are they willing to help to enter the bus?
Lighting	Is turned off at night for energy-saving reasons, at least outside the built-up area (see traffic design).
Sounds	Lack of sound, e.g. the sound of traffic lights switched off after 8 pm (see traffic design).
Parking	Do priority parking places adhere to the guidelines? Are they placed well? also issues of placement and shape.
Traffic rules/regulations	e.g. the rule in Zwolle: when there is no footpath, walk on the cycle lane.
Routes/directions	How to get from A to B; if there are temporary obstacles, alternative routes are required.
Barriers for access	People with auditive impairment require an alternative to sound/spoken text.

Throughout all sessions, it was emphasized how important it is to take a cross-disability perspective and consider the diverse and potentially conflicting views of different types of urban residents depending on their abilities and disabilities. For example, single-level pavements may increase accessibility to wheelchair users while at the same time making it more difficult for people with visual impairments to use the tactile pavement to navigate.

From all the activities we elicited user requirements for the mapping tool implemented on a maptable. These include both requirements regarding the hardware, i.e. the maptable, the environment in which it is used, and requirements related to the software of the mapping tool.

Requirements regarding the hardware and the environment in which the maptable is used are: To make the touchscreen of the maptable accessible for wheelchair users, the screen needs to be tiltable and should not exceed a screen size of 49 inches, to allow users to touch all corners of the screen. The screen needs to be adjustable in height to allow its use while standing as well as sitting around it. Regarding the environment in particular the lighting of the room is important as direct light onto the screen might lead to reflections that limit its visibility.

Software requirements for maptable tools can be distinguished into general tool requirements independent of the content and context of the tool and requirements specific to the topic of accessibility to public space. Content-independent requirements are described in Table 3. It is worth mentioning here, that all requirements are of general relevance with respect to the usability of tools and can be applied to all kinds of maptable tools for different contexts of use and users regardless of the level of disability.

Table 3. Generic features of the inclusive mapping tool

Context-specific software requirement	Description
Contrast text to background (interface and map layers)	Contrast ratio at least 4.5:1 (minimum), optimum is 7:1
Text font	Use text fonts sans serifs
Text size	Large text size is needed for people with visual impairments, never encode information with absolute text sizes, use relative sizes instead
Text spacing	For some people, more text spacing is required between letters as well as between words
Full-screen view of tool	To avoid distraction for people with visual impairments
Street search	To support the identification of locations and navigation for people with limited map literacy
Photos/images	Include ALT attributes for images, better provide utility descriptions than literal descriptions

Specific features to be included in the tool for mapping accessibility to public space are listed in Table 4. They are closely related to the purpose of the tool, which was defined together with the co-researchers as:

- Reporting of problems and good solutions for accessible public space online
- Using the reported data in collaborative decision-making workshops

The key feature of the tool for reporting purposes is a dialogue that allows users to add spatial locations of a problem or good solution to the database. Next to the classification of the mapped problems in the categories detailed above (table 2), a short verbal description of the problem and the visualization of the problem with a photo turned out to be helpful for participatory sessions. For people with visual impairments, it is essential that both the verbal description of the problem and the content of the photo is stored as text that can be read aloud by the system. Finally, for supporting the joint definition of mitigation measures such as selecting alternative routes for wheelchair users in case of temporal barriers, it is helpful to visualize aerial photos as background layers for different seasons, e.g., with and without leaves on the trees.

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Table 4. Preliminary list of context-specific features of the inclusive mapping tool

Generic software requirements	Description
Mapping physical barriers (permanent and temporal)	Mapping points features into different categories (see table 2)
Photo capturing	Integrating georeferenced photos taken with a mobile app into an existing layer
Visualizing georeferenced photos of barriers	Clicking on photos visualized as thumbnails in a layer displays these photos in a separate window
Capture spoken words as text for single photos	Select a photo from the layer above and record text into an attribute or audio signal
Aerial photos of different seasons (winter/summer)	Showing vegetation with and without leaves; to support the identification of routes and locations

A screenshot of the draft tool prototype is shown in Figure 3. The figure shows the dialogue for mapping problems of access to open space in the city of Zwolle.

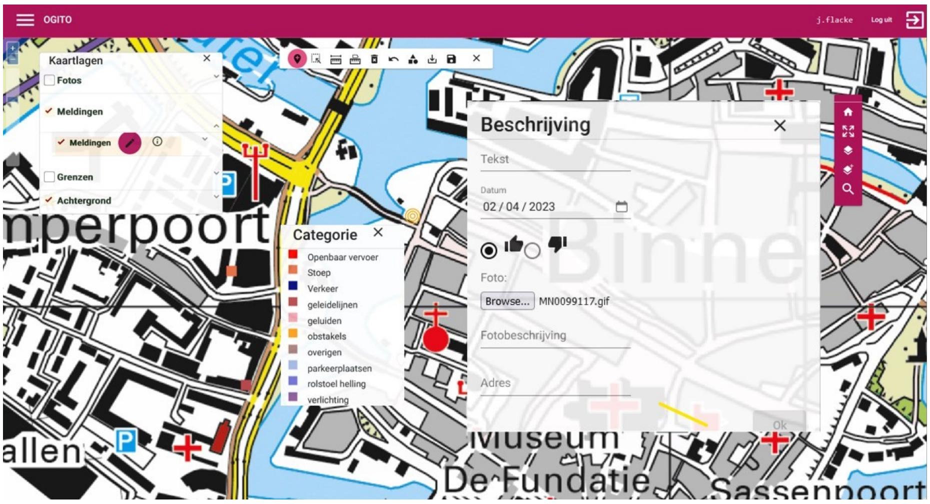

Fig. 2. Screenshot of the draft tool prototype in Dutch. Meldingen (left box) means reporting. The box in the center allows a user to select the category of the problem (see table 2). The box on the right requests the details of the problem (text, photo, date, etc.)

5 Next steps and preliminary conclusions

This paper reports the current state of the art from an ongoing project. The findings so far on our three analytical questions reveal various challenges on the way to the inclusive city as well as in developing an inclusive mapping tool. For instance, the design of public space from a cross-disability perspective leads sometimes to conflicts of solutions between the needs of diverse groups of people with disabilities. Here trade-offs and compromises have to be found. In the next steps, we will explore how far the mapping tool might be beneficial in mitigating such trade-offs.

Likewise, the design of an inclusive mapping tool requires decisions regarding user needs. So far, we have for instance not been able to accommodate people with limited fine motoric skills or for the blind. This is partly due to the fact that this would require the use of proprietary hardware (joystick so people can operate the system without using the touchscreen) or software (voice command and text-to-speech or text-to-braille applications) which we do not have access to or have not been able to integrate yet. Moreover, a fully inclusive mapping tool also requires the involvement of people with cognitive disabilities in its design.

Next steps will be the testing of the tool prototype by the co-researchers in three iterations and its refinement accordingly. Once a final prototype is available it will be applied and evaluated in a collaborative mapping workshop by the co-researchers and additional stakeholders from the city of Zwolle.

Finally, many issues found are likely to improve the usability of maptable tools for the general public with diverse abilities and disabilities. The final design and functionality of the mapping tool and the evaluation of its usability and usefulness will be presented at the CUPUM conference 2023.

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