Project number 875022

Smart Mobility Hubs as Game Changers in Transport

WP4. SmartHubs Living Labs

T4.5. Munich Living Lab implementation of the Mobility Hubs

Deliverable D 4.5

Living Lab implementation report Munich

Version: 0.2
Date: 10.05.2023

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This project is supported by the European Commision and funded under the Horizon 2020 ERA-NET Cofund scheme under grant agreement Nº 875022

DOCUMENT CHANGE RECORD

Version	Date	Status	Author	Description
1.0	27/03/2023	Draft	David Duran, Fernanda Navarro, Aaron Nichols, Benjamin Büttner	First draft
1.1	10/05/2023	First Version	David Duran, Fernanda Navarro, Aaron Nichols, Benjamin Büttner	Revised version

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EXECUTIVE SUMMARY

The Munich 2035 mobility strategy aims to enhance the quality of life, accessibility, inclusion, and participation by expanding public transportation, cycling, and walking options, as well as shared mobility services, car-free planning, and optimizing traffic light systems. To achieve these goals, a living lab was established to co-design and implement a mobility hub. This mobility hub aims to promote the use of active and shared modes of transportation, foster a sense of community, and create a more livable environment. The living lab is located near the Technical University of Munich, an area with high traffic density and many amenities, making it an ideal location for the mobility hub.

An existing parklet was selected to be transformed into a mobility hub, featuring a sitting area with an area for exchanging objects, lighting, bike parking, and plants. Since many features of the parklet are in line with the goals of the living lab, the parklet's infrastructure was improved to create a mobility hub that is easy to use, provides other activities beyond mobility, has a cozy design, is a place to stay, and provides barrier-free access within 100 meters of the nearest public transport stop.

To identify citizens' needs for the mobility hub and enhance the parklet, three approaches were taken, including an on-street panel, a co-creation game, and a survey. The results showed that the mobility hub needs to include elements such as bike parking, bike repair station, seating, e-scooter parking, wayfinding, inclusive information, urban gardens, cafes, and kiosks. The survey showed high interest in using shared-bikes and shared-scooters, with less interest in shared-cars and shared-mopeds. Participants also showed more interest in having an application, information, an attractive design, and different services, rather than having different mobility options. Based on these results, the parklet was adapted according to the main needs of people to transform it into a mobility hub.

The evaluation of Munich's Living Lab involved collecting feedback from users through an on-site survey and workshop, evaluation of key performance indicators, a feedback session with stakeholders, and a multi-criteria and multi-actor appraisal tool. A short survey was conducted to collect information about user experience, improvement opportunities, and additional elements for future mobility hubs. The survey results showed that 65.2% of respondents were between 22-25 years, 50% of respondents were women, and 47% were men. 90% of respondents used the space as a place to stay, and 36% used the various mobility services provided. Users gave positive feedback on the quality of facilities, including wayfinding, lighting, safety, and quality of waiting areas, public transport infrastructure, and sharing services. The majority of respondents were pleased with the safety conditions and lighting, while comments suggested adding more plants,

charging options, and more space. The survey also highlighted that the public transport infrastructure was in close proximity, while the sharing modes options were not available.

Regarding the stakeholders from the planning field, the given feedback indicated they agreed on reusing existing infrastructure for future mobility hubs, and they suggested applying co-design approaches to enhance engagement and acceptance from citizens. Moreover, stakeholders emphasized the difficulty of bringing together all entities working on mobility hubs to share and combine ideas, and highlighted the importance of including more transport opportunities and finding locations that offer sufficient mobility opportunities. They also recommended focusing more on behavioral changes after implementation to approach developers for future projects.

Lastly, we applied the Stakeholder-based Impact Scoring (SIS) appraisal tool, a participatory appraisal method that quantifies the negative and positive impacts of projects on stakeholders. The appraisal tool showed that the hub has more positive impacts on criteria (e.g. infrastrucutre, mobility options, visibility, cleanliness, etc.) defined by different stakeholders (citizens, transit operator, city of Munich) than negative ones, and is more in line with the interests of citizens, followed by the mobility department of the city of Munich and the public transport operator. The hub's location outside the network of hubs in the city is a drawback for the city of Munich, and for the public transport operator, the fact that the hub is not directly located at a public transport station is a challenge, while the main positive impacts for citizens include the multiple mobility services, various other activities that can be performed at the hub, and the cozy design.

1. INTRODUCTION

This report provides a summary of the Munich Living Lab in the context of the Smart Hubs project. It begins with an explanation of the overall context and goals of the living lab (Section 2). Section 3 covers the planning procedure for the mobility hub, including the location selection process and the various hub elements. Section 4 presents the evaluation of the hub's design by different stakeholders. Finally, Section 5 provides a summary of the living lab process and results.

2. LIVING LAB SET-UP

2.1.City context

Munich, the capital of the Federal State of Bavaria in Germany, has a population of 1,588,330 inhabitants, according to the most recent figures (Statistisches Amt München, 2022). In 2021, approximately 42% of the city's population was made up of adults between the ages of 18 and 44 (Rzehak, 2022). Regarding the mobility characteristics of the city, 56% of Munich's households have at least one registered private car, 83% of the population owns a bicycle or e-bike, and 47% of the population owns a seasonal ticket for public transport services (Nobis & Kuhnimhof, 2018).

According to the MiD (Mobilität in Deutschland) (2017) travel survey, 35% of people in Munich perform intermodal trips that combine the use of private car, public transport, and/or bicycles (Belz et al., 2020). Additionally, 21% of the households in Munich have a car-sharing membership (Belz et al., 2020). According to the travel survey, only 3% of people in Munich use bike sharing at least on a monthly basis and 88% of the population almost never uses bike sharing. A more detailed look at Munich's modal-split is presented in Figure 1. The available data also shows that, in Munich, about 16% correspond to short trips (less than 5 km), 15% are between 5 and 10 km, 21% are between 10 and 20 km, and 36% are longer trips (more than 20 km), while about 12% of Munich residents are not mobile (Belz et al., 2020), refer to Figure 2 for more details on the traveled distances.

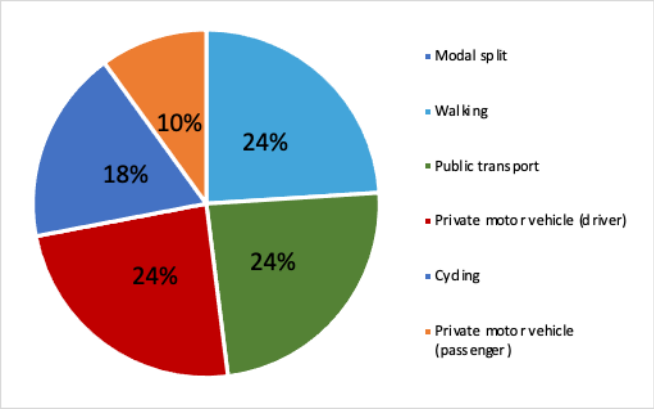

Figure 1. Modal split for the city of Munich. Source: (Belz et al., 2020)

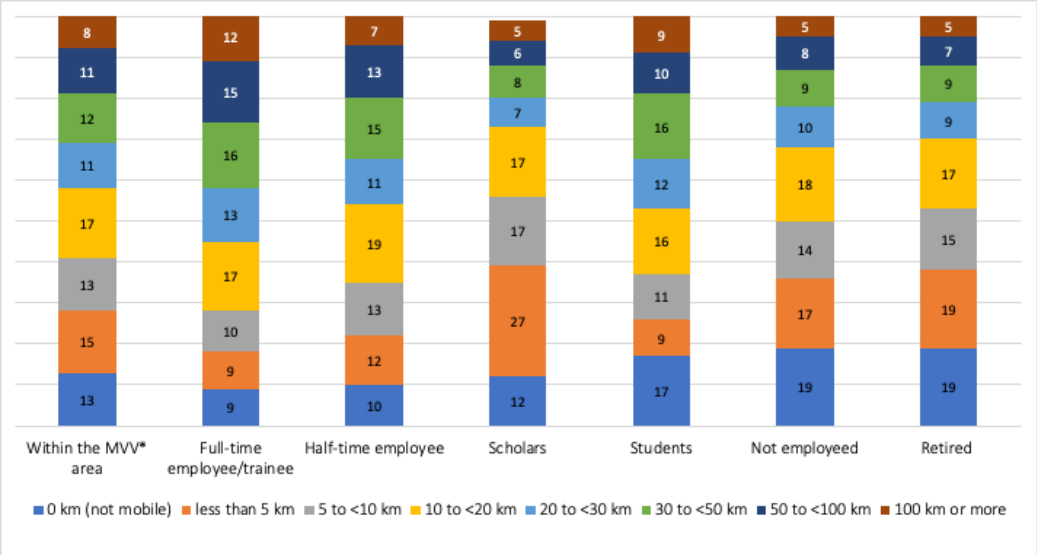

Figure 2. Traveled daily distances by social groups. Source: (Belz et al., 2020)

Public transport services are offered by the Münchner Verkehrsgesellschaft (MVG), which provide subway, tram, and bus services. Additionally, Deutsche Bahn (DB), Germany's national rail provider, operates the S-Bahn network, which connects suburban areas and small towns in the Munich region to the central city. In addition to the traditional public transport services, other mobility services such as bike sharing, car sharing, e-moped/motorcycle sharing, and shared e-scooters are available in Munich as well.

In addition to the previously mentioned transport services, Munich's transportation infrastructure also includes mobility hubs, sometimes called "Mobilitätsstationen (mobility stations) or "Mobilitätspunkte (mobility points). They can be identified by an information pillar that displays information about the available transportation services (*Mobilitätsstationen im MVV*, 2023). A map is also usually available. The best example of one of these hubs is the Münchner Freiheit (https://data.smartmobilityhubs.eu/wiki/Hubs/68) subway station. It was turned into a mobility hub in 2014 and is still in operation as a mobility hub. Besides public transport (subway, tram, bus), shared mobility services are available in this hub.

The city of Munich has planned a mobility strategy for the year 2035 that envisions a city with fewer cars, more use of sustainable and inclusive transport modes, cycling infrastructure through and across the city, public transport supported by on-demand services in less covered areas, parking spaces transformed into public spaces for the people, and multimodal stations (mobility hubs) scattered throughout the city (Landeshauptstadt München, 2023). By 2026 the city aims to have 200 mobility hubs adding to the 17 existing Mobilitätspunkte under operation with the goal of making sharing services more accessible and visible for the users. The idea is to reduce private car dependency and encourage intermodal trips (Landeshauptstadt München, 2023). In addition, this strategy also seeks to improve parking conditions for micro-mobility sharing options (e-scooter, bikes, e-bikes) and for car-sharing by creating 1600 new spaces (muenchen.de, n.d.). Lasty, another important aspect is that the strategy is being implemented by Public Transport Operator (MVV), MVG and other service providers (muenchen.de, 2022).

One of the main goals from the mobility strategy established for 2035 is to ensure that at least 80% of the traffic in Munich's metropolitan area correspond to zero-emission motor vehicles, local public transport, and active modes (walking and cycling) (Landeshauptstadt München - Mobilitätsreferat, n.d.). So far, the introduction of sharing micro-mobility services has been accompanied by problems related to the drop-off location. According to the strategy, this has been the main complaint related to e-scooters as they are frequently found in the middle of the streets. For this reason, the city has designated parking areas to reduce conflict between different travelers, for instance, blocked sidewalk for pedestrians. The goal of the city is to implement marked parking areas combining multiple sharing services. Even though mobility hubs have existed in Munich for almost a decade, there has been very little digital integration of the services until now. MVG, Munich's public transport provider, has developed an app where the users can access real-live public transport information as well as book public transport tickets and sharing services provided by MVG and other partner providers (TIER and Voi).

2.2.Living lab goals

Beyond the intermodal connections, further goals of the mobility strategy in Munich 2035 includes the quality of stay, accessibility, inclusion and participation. Specific actions in this strategy include:

- Massive expansion of public transport, cycling and walking options, and shared mobility services.
- Car-free planning and restructuring of new developments and existing neighborhoods.
- Redistribution of street space and optimized traffic light systems in favor of environmentally friendly modes of transportation.
-

In order to align with the strategies of the city, the goal of this living lab is to adapt existing infrastructure, co-design, co-evaluate, and implement a mobility hub by removing car-parking spaces and promoting the use of active and shared modes of transportation. At the same time, the focus is to encourage people to engage at the hub in activities beyond just mobility and to create a more liveable environment. The design of the infrastructure aims to be simple to use, and barrier-free.

The living lab had two primary target user groups that play a significant role in the area: local residents and university employees and students. These groups were chosen to support the integration of the community living next to the Technical University in Munich, with the aim of fostering a sense of community and encouraging students to interact with and learn from the residents.

Additionally, the Munich living lab set out to improve the urban cycling experience by providing a self-repair bike station for the convenience of the cyclists. Concerning user experience, the hub aimed to foster seamless connectivity through better information about the time and location of different public transport modes in the area. It is relevant to highlight, that the living lab aligned with the city's goal to increase parking spaces for sharing services and, therefore, reduce potential

conflicts between modes, especially with pedestrians, and make sharing services more accessible in the area.

Referring to the SmartHubs integration ladder (Figure 3) (Geurs & Münzel, 2022), the hub planned in the Munich lab aims to achieve a physical integration level of 4, a digital integration level of 0, and a democratic integration level of 3. Concerning the physical integration, the goal is to locate the hub within an acceptable walking distance from bike-sharing stations and public transport stops, while also providing wayfinding and branding information with minimal visual obstructions. Additionally, the hub will offer services beyond just mobility, with a cozy and sustainable design that promotes placemaking. To achieve democratic integration, the city of Munich, the Public Transport Operator (MVV), and citizens are part of the co-design and co-evaluation approaches to establish the elements to be included in the hub's design. This living lab does not consider the digital integration.

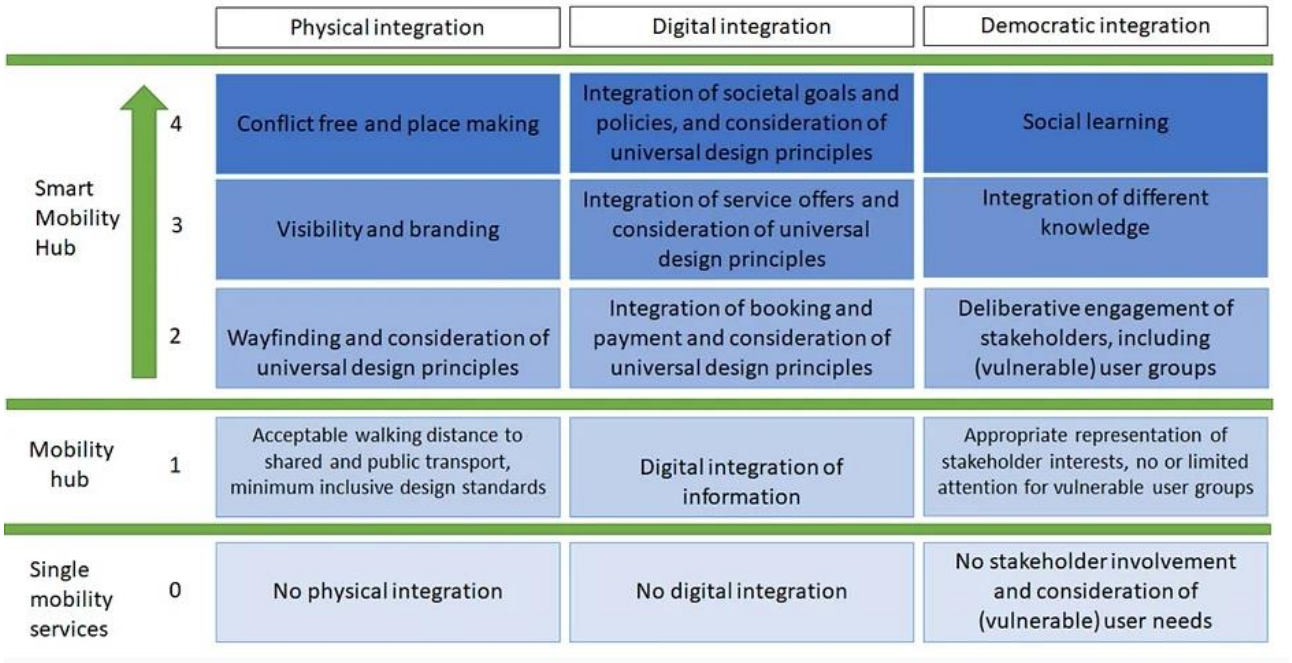

Figure 3. SmartHubs Integration Ladder. Source: (Geurs & Münzel, 2022)

2.3.Local context of the living lab

Mobility hubs have been operating in the city of Munich for several years now, and plans are underway to add 200 new stations in the short-term. This presents a great opportunity for political support, as well as an indication that a percentage of the population is already familiar with the concept and services offered by mobility hubs. In a survey with 516 participants from the SmartHubs project, 70,7% of the participants have seen mobility hubs, and 50,5% of those who has seen a hub, has used it (Figure 4).

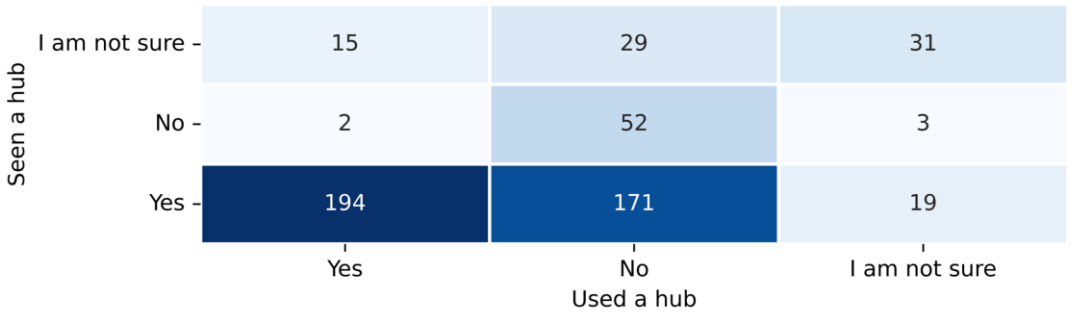

Figure 4. Mobility hub awareness in Munich

The Munich living lab was planned to be set up in the vicinity of the Technical University of Munich (TUM), having as main target users students and employees from the university and residents. The selection of the area of implementation was linked to the high traffic density (flow) in the area, both for active and motorized modes. Additionally, the district (Maxvorstadt) has plenty of amenities (university, local shops, restaurants, retail, entertainment) and, at the same time, is well served by public transport.

Moreover, according to Klanke (2022), there is a high parking demand from employees and residents commuting to and from the area, which together with a reduction of the parking spaces to create new cycling lanes during the Covid-19 spread has become a pressing issue. Nonetheless, with a bike lane in the area, the traffic of cyclists is also prominent, another positive aspect to consider for the site selection. Furthermore, considering the proximity to the university, the students and employees, alongside the residents of the area, represent a constant flow of potential users. In addition, this is enhanced by the high concentration of points of interest, as mentioned before.

3. LIVING LAB PLANNING

3.1.Defining the Living Lab location

The area selected to plan the hub around the technical university has a significant potential considering three main conditions typically related to mobility hubs' characteristics. Following the guidelines for the integration of mobility hubs (SmartHubs Deliverable 3.1) into the urban space (Duran-Rodas et al., 2022), high concentration of points of interest (services, activities, etc.), existing public transport coverage, and high traffic/demand potential. The university surroundings offer a wide variety of services like supermarkets, entertaining venues (museums, galleries, etc.), bike-sharing services, charging stations, restaurants, and cafes. The public transport coverage in the area includes two subway (U-Bahn) stations (1 line), and three bus stops (3 different line services). In addition, tram stops are located approximately 200 m from the main campus (see

Figure 6).

To choose the precise location of the hub, relevant existing infrastructure in the area was considered as a basis for the development of the mobility hub. Finally, an existing parklet in the surrounding of the university was chosen. The location of the parklet is shown in

Figure 6. This parklet was developed as part of a summer school, in which it aimed to remove three parking spots and repurpose them (). The parklets' main elements were seating spaces, an area for exchanging objects, lighting, bike parking, and plants.

The focus on the living lab is to use the existing infrastructure of the parklet and transform it into a mobility hub. The parklet meets the goals of the living lab, being easy to use, have other activities besides mobility, have cozy design, provide a place to stay and barrier-free access, and being located within 100m of the next public transport stop.

Before:

After:

Figure 5. Transformation of the car parking area into the parklet

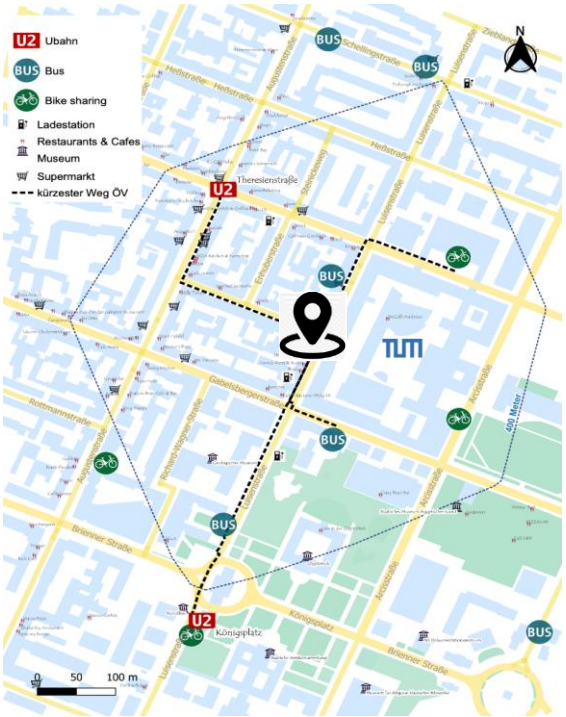

Figure 6. Representation of the services, amenities, and transport modes available in the area of interest

3.2.Citizens' needs

After identifying the location for the living lab, the next step was to gather additional perspectives from the citizens. To identify their needs, three approaches were implemented in the living lab:

i. **On street panel.** This was an initial approach to identify the potential users' "**wish list**".
ii. **Serious board game**. Co-design game created to determine the elements needed in a hub close to the university. The game was played three times, first with students (n=150), the with students that are also residents of the area (n=40), and in a street festival (n=18).
iii. **Survey**. Survey by the SmartHubs project (n=516).

3.2.1. On street panel

On street panel in a street festival at the university. People that passed by could pin what they wish in a mobility hub. As a summary (Figure 7), people mainly suggested:

a. Bike-related services (bike washing station, repair station, bike-share station, bike parking).
b. Other activities than mobility (e.g., sports, toilets, kiosks).
c. Green areas.

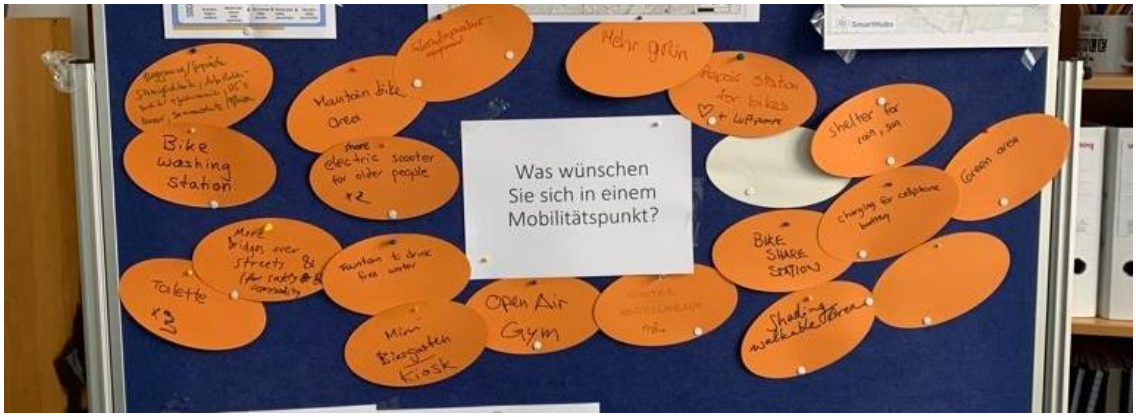

Figure 7. On-street wish list

3.2.2. Serious board game

Game description

The serious board game is a co-creation game designed to identify the elements that players wish to have in a hub. Furthermore, the game encourages the participants to design inclusive mobility hubs by introducing characters vulnerable-to-exclusion (v2e) as potential users. The game's goal is to identify the elements that players consider/wish to have in a new mobility hub. The maximum number of elements the players can choose is six, representing the limited spaces and resources that can be part of the hub's design process. Additionally, they are encouraged to negotiate and prioritize, selecting only a few elements from all the provided options.

The game set includes a board with a potential location of a mobility hub, representation of v2e personas through cards or a QR code leading to a website (www.cardsforhumanity.com), and 50 cards of potential elements of the hub (including blank cards). The element cards (Figure 8) are based on essential elements of mobility hubs, including mobility opportunities (Aono, 2019; Geurs & Münzel, 2022; Schemel et al., 2020), placemaking elements (Aono, 2019; CoMoUK, 2019;

Metrolinx, 2011; Urban Design Studio, 2016), inclusive design guidelines (*The 7 Principles | Centre for Excellence in Universal Design*, n.d.), and wayfinding characteristics (Aono, 2019; CoMoUK, 2019; Johansson et al., 2021; Miramontes, 2018; Monzón et al., 2016). Additionally, each team receives blank cards to add any other element not previously represented. The cards (physical or digital) represent people with different traits that might make them v2e users in transportation. These included visually impaired users (totally or partially), people with physical and cognitive limitations, and people with mental conditions. These characters also match v2e previously identified in the literature (Bogren et al., n.d.; Nybacka & Osvalder, 2019; Ongel et al., 2018).

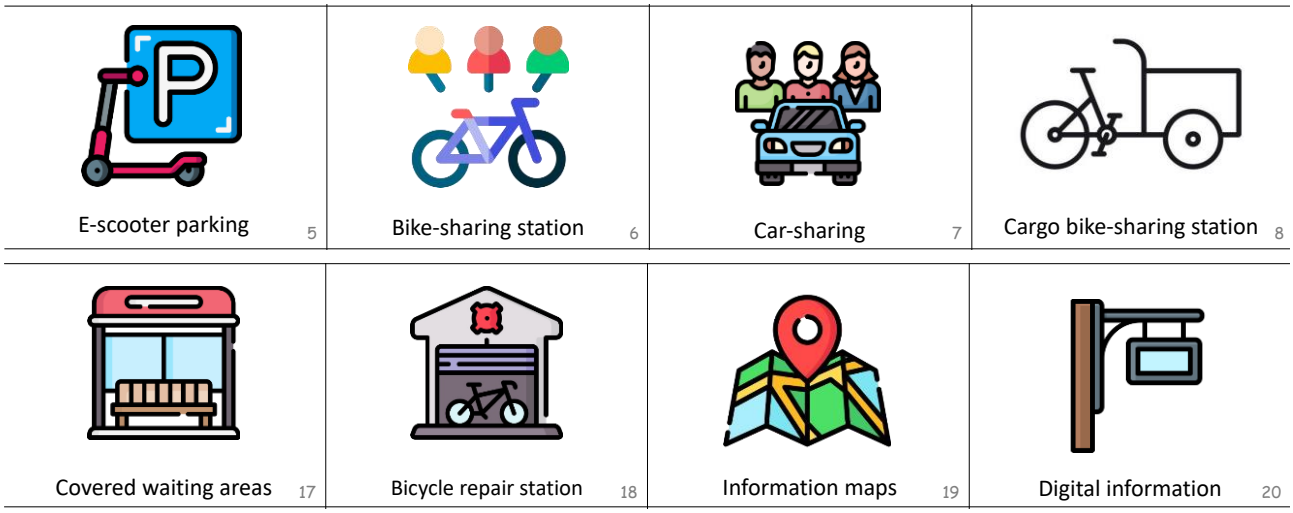

Figure 8. Example of the elements represented in the game for the players to choose

The game was created for teams of 2, 3 or 6 players and though to be played by various teams simultaneously. It follows a hierarchical order of three phases:

- Phase I: The v2e people cards should be face down, and the element cards should be face up. Each player should choose an element card. When the game is for 2 and 3 players, each player should choose 3 or 2 cards, respectively. After choosing the 6 elements, the players can discuss and negotiate to remove or add one or more elements.
- Phase II: Randomly, each team chooses a v2e card. They can remove one or more elements to meet the needs of the v2e persona they represent.
- Phase III: Two groups are merged. The players can discuss and negotiate to choose the final 6 elements they want to incorporate to the hub, considering also the two v2e personas they were assigned.
- Optional phase: To incorporate the competitive factor into the game, a jury can vote and select the "best design" or the “best selection of elements” for the hubs.

Game application

The game was applied three times, with each session involving different stakeholders' groups (see

Figure 9

Figure 9). The first session was conducted with citizens who attended a public mobility event on the street. The 18 participants who tried out the game communicated to the team that they commonly pass by the area when going somewhere else. This means that even if they are not residents or work in the area, they are still relevant stakeholders as they move through the neighborhood, making them potential users of the mobility hub. A second game session took place with 40 students who were also residents of the neighborhood. The third and final session was conducted with 150 students.

Figure 9. Photographs taken during the three implemented game sessions.

The final elements selected by the teams in each session were documented to determine the components that should be included in the living; the results are presented in Figure 10.The final components were classified into 3 categories; i.e., mobility elements (related to the use of different transport modes), information (for seamless navigation), and those elements associated with the urban form (placemaking elements, services, etc.). Based on the co-design game's results, Figure 11 summarizes the most frequent elements the various stakeholders wished to find in the mobility hub.

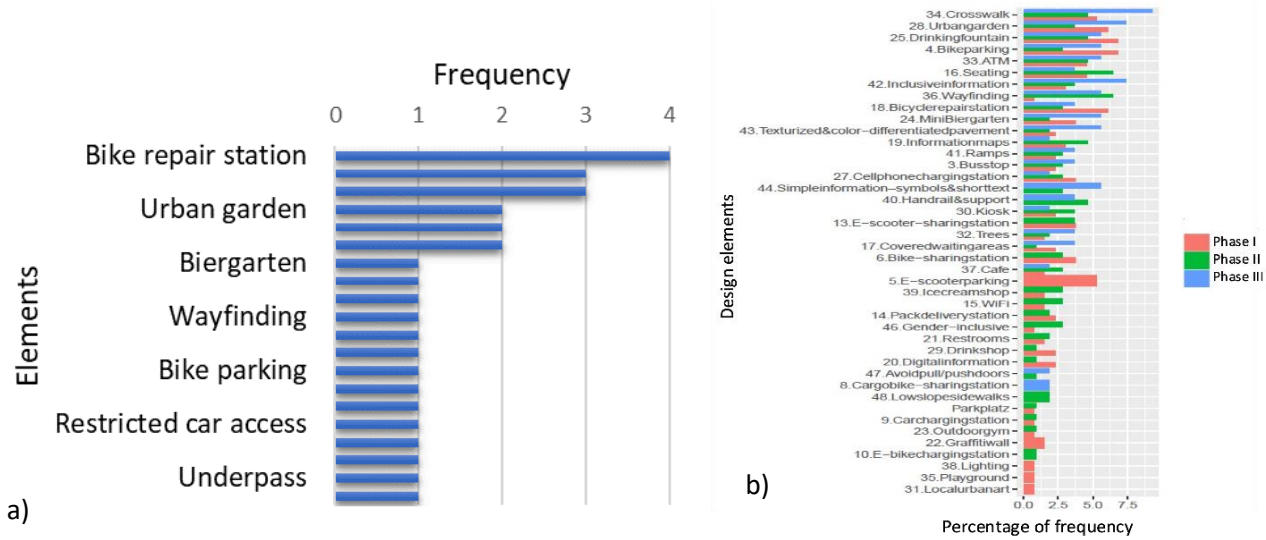

Figure 10. Selected elements by the participants' teams by a) the residents from the Oskar-von-Miller Forum and b) university students

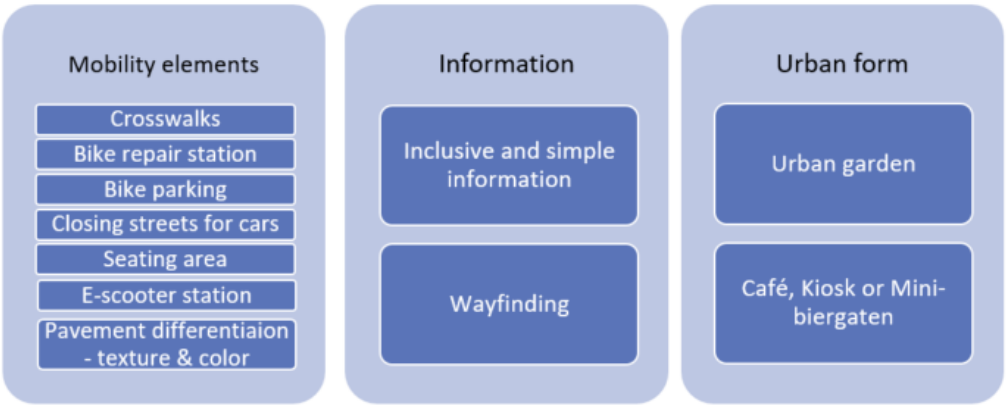

Figure 11. Identified elements to be incorporated into the mobility hub based on the participants answers in the co-design game

3.2.3. Survey

In a survey conducted as part of the SmartHubs project (December 2022-January 2023), 516 participants in Munich expressed a predominantly strong interest in using in mobility hubs shared-bikes and shared-scooters, while showing less interest in shared-cars and shared-mopeds (Figure 12). Regarding the services in general, participants demonstrated high interest in having an application, access to information, an attractive design, and different services, rather than having different mobility options (Figure 12Error! Reference source not found.).

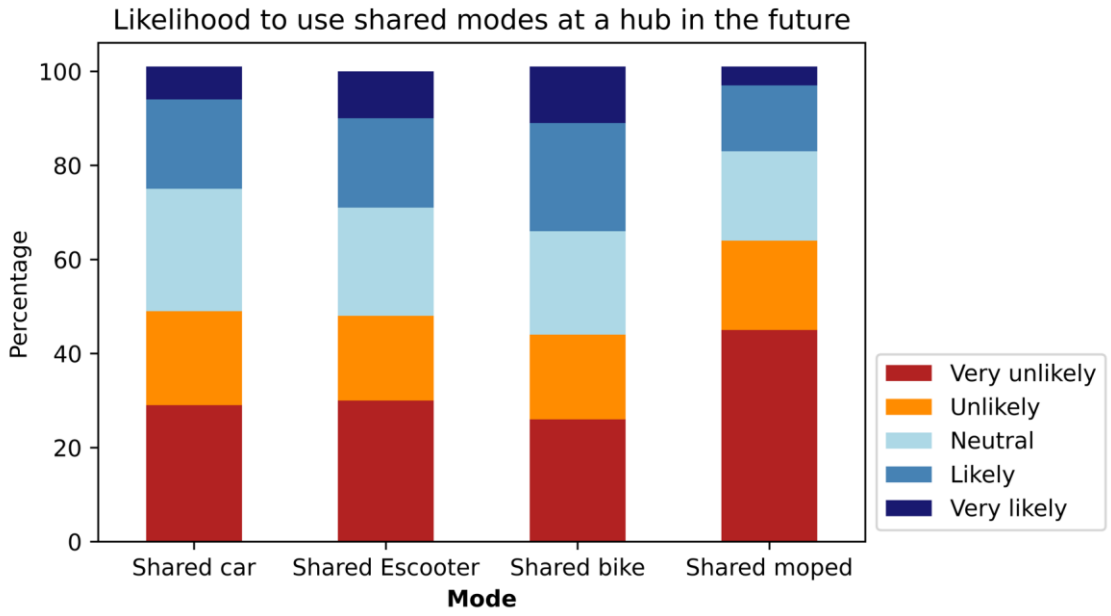

Figure 12. Likelihood of using shares services in the future in Munich

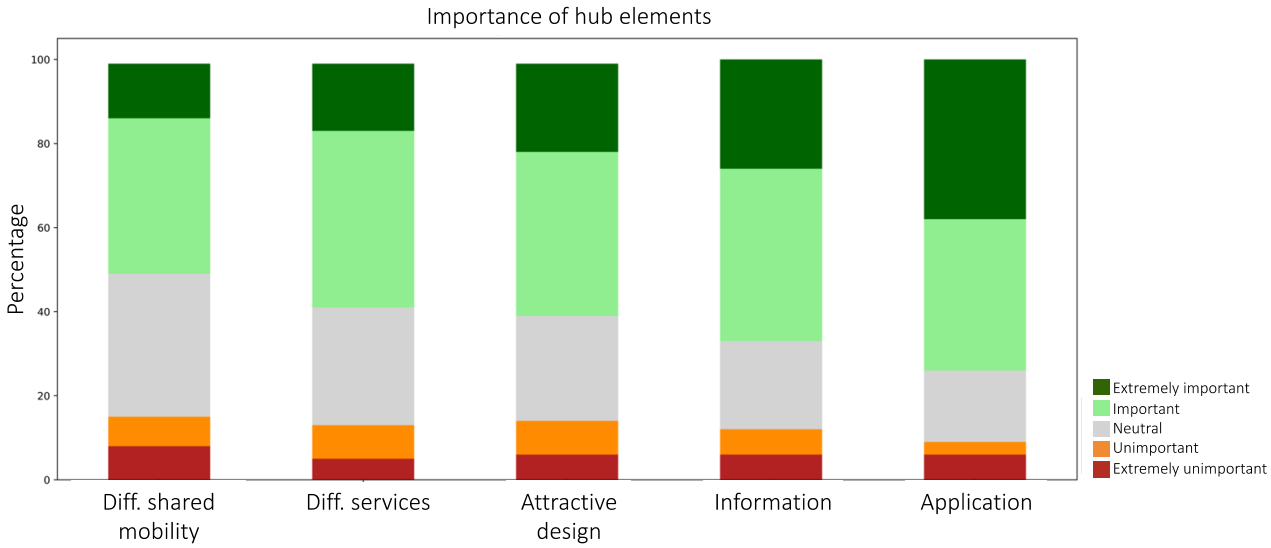

Figure 13. Importance of hub elements

3.3. From parklet to mobility hub

The results of the game and the other applied methods were the basis for identifying which elements needed to be added to the existing infrastructure. Some of these elements were already found in the parklet (Figure 14). The parklet already provided bike parking, a seating area, an urban garden, and a café place that could be found around the corner, and, although not a kiosk itself, the parklet integrates a shelf to give away items such as books, plants, decoration, etc.

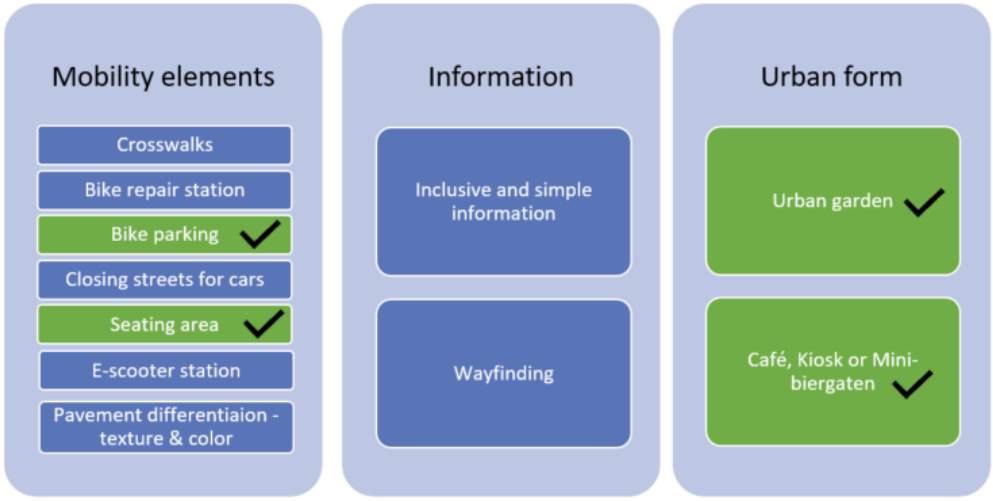

Figure 14. Potential users' desired elements already incorporated into the parklet

Most of the remaining aspects were feasible to incorporate to convert the parklet into a mobility hub, enhancing the user experience and improving the accessibility. The added elements to the parklet were a bike repair station, an e-scooter station, wayfinding elements, and information components. The design of the signs included information on different transport modes, as well as for wheelchair users. As part of the wayfinding elements, the modifications required the addition of a map to help users locate points of interest nearby (Figure 15). Additionally, the information pillar would include the name and logo of the SmartHub to facilitate recognition and visualization.

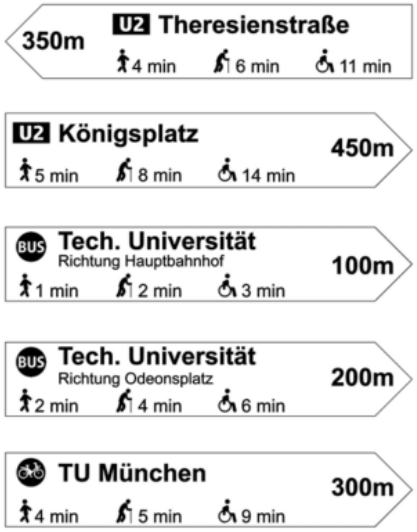

Figure 15. Design of the signs

With these added components, from the elements prioritized by the stakeholders, only two aspects remained (Figure 16), i.e., crosswalks, and the prohibition of car access to the street. Unfortunately, since these interventions would alter the public infrastructure, its implementation would require more time and permits. Hence, it is not feasible to adapt the space in this regard.

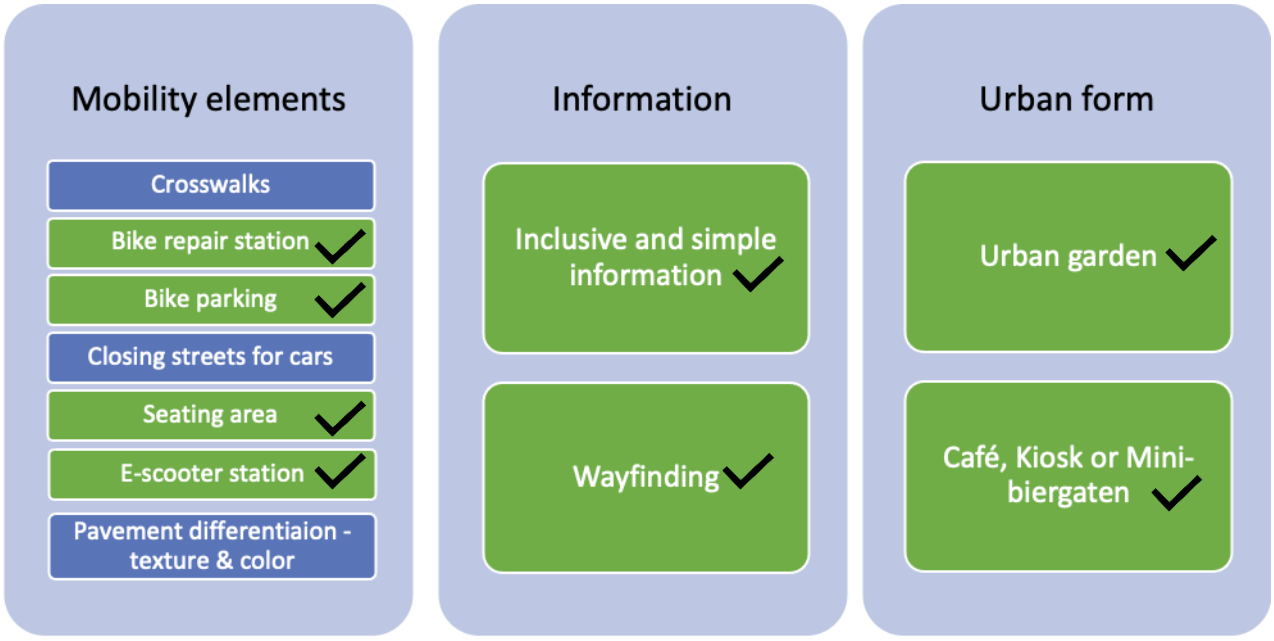

Figure 16. Evaluation of the potential users' desired elements vs. the elements implemented into the hub

Figure 17 shows the final result of the mobility hub. Figure 18**Figure 18** presents the elements related to mobility and some examples of people using the different services (A: shared bikes and e-scooters, B: baby wagon, C: delivery bikes, D: bike repair station).

Figure 17. Parklet to mobility hub result

Figure 18. Munich's living lab under operation - mobility usage

4. LIVING LAB EVALUATION

The evaluation of Munich's Living Lab involved collecting users' feedback through an on-site short survey and workshop, and assessing the key performance indicators presented in the SmartHubs Deliverable 2.2 (Pappers et al., 2022). Additionally, a feedback session was conducted with stakeholders from the mobility department of the City of Munich and the public transport operator. Finally, the evaluation was supplemented by a multi-criteria and multi-actor appraisal tool, SIS, developed by Vrije Universiteit Brussel (Te Boveldt, et al. 2022).

4.1. Evaluation of Key performance indicators

4.1.1. KPIs based on on-site observations and online research

Table 1 and 2 provide the core KPIs evaluated for the mobility hub, these were selected from the KPIs presented in the SmartHubs Deliverable 2.2 (Pappers et al., 2022) based on the applicability to this Living Lab. The evaluation was done through onsite observations or online research. The KPIs are measurable criteria to assess the mobility hub's impact across the topics of mobility, services, digital components, accessibility, safety, and democratic contexts.

Table 1. Evaluation of non-essential KPIs for Munich's Living Lab

Category	Indicator	Evaluation	Comments/Questions
Mobility	Crowding at the mobility hub	Lunch time & afternoon	
	Parking capacity at the hub	0	
	Availability of kiss&ride places to drop off/pick up passengers	No	
Services	Presence of printed timetable displays	No	
	Presence of display with overview of points of interest near hub	Yes	
	Spaces adapted to storing items (e.g., left luggage facilities)	No	
	Amenities adapted for freight vehicles to unload (e.g., to deliver parcels to parcel lockers)	No	
	Presence of commercial activities	Yes	
	Availability of toilets	No	
Digital	Presence of digital manuals explaining use of modal options at the hub	No	
	Presence of free wireless internet	No	
	Availability of QR codes for fast user registration and use of mobility options	For sharing services	
Safety and security	Security cameras in operation	No	
Democratic integration	The number of citizens participating in the design of the hub	More than 200	Participants of the co-design game.
	The number of ways users can submit suggestions or complaints	1	Onsite: box for suggestions and feeback.
	Number of dialogic participation opportunities	3	Co-design sessions
	Number of one-directional participation opportunities	0	
	Number of online/digital participation opportunities	0	
	Number of online announcements	0	
	Number of printed announcements	0	
	Number of on-site announcements	0	

Table 2. Evaluation of core KPIs for Munich's living lab

Category	Indicator	Evaluation	Comments/Questions
Mobility	Public transport frequency	18 buses, 24 U-Bahn (subway)	Tram service was not considered since the
	Number of transportation modes at the hub	4 (bus, subway, e-scooters, bike sharing)	
	Number of public places adapted to leave a bicycle/moped/scooter	2	
	Number of vehicles available at the hub	Not fixed number / sharing services are dockless	
	Possibility to buy ticket that combines several modes	No	
	Availability of drop-off/pick-up points for taxi/carpooling/ridesharing/ridesourcing	No	
	Integration with local/regional/national transport policy	No, not direct integration but aligns with the local plans	
	Number of hubs in the network	0	
Services	Presence of overview of location and explanation of mobility options	Yes	
	Availability of ticket machines	No	
	Spaces adapted to pick up packages	No	
Digital	Availability of digital ticketing (incl. mobile applications, smartcards, and digital ticket machines) per service provider and/or hub operator	No	
	Presence of a digital map to find locations of modal options at the hub	No	
	Availability of real-time departure and arrival information for public transport at the hub	No	
	Availability of real-time information about the availability of shared mobility options	No	
	Possibility to plan a trip in a digital travel planner in which all modes available at the hub are taken into consideration	No	
	Possibility for users to unlock vehicles and facilities, e.g. using a smartphone, a code, a card	Yes	
	Number of applications/subscriptions necessary for full use of the hub and its services	2 or more (depending on sharing services)	Public transport ticket and sharing services (multiple providers). There is no integration.
Accessibility	Presence of physical or digital overview of information for people with disabilities	Yes	
	Accessibility of the digital mobility services and facilities at the hub for people with disabilities	No, no digital services provided by the hub	
	Accessibility of transport modes for people with disabilities	Yes	
	Accessibility of hub facilities for people with disabilities	Partially	Accessible facilities. Information and infrastructure for the visually and hearing impaired is missing. Sharing services are not physically accessible for all type of users
Safety & security	Proportion of secure bicycle parking	0	
Democratic	The involvement of (representatives of) vulnerable-to- exclusion citizens in designing the hub	0	Possible interview with vulnerable groups?
	Number of in-person participation opportunities	3	

4.1.2. KPIs based on-site (users) short survey

To evaluate subjective KPIs, a brief survey was available for the users at the hub (Figure 19**Figure 19. On-site survey**). The short survey aimed to gather information about the user experience, identify improvement opportunities and additional elements they wished for a future mobility hub.

The user experience evaluation involved the use of the facilities, and the satisfaction level concerning essential elements from a mobility hub (also based on the KPIs guideline) such as wayfinding, lighting, safety, and the quality of waiting areas, public transport infrastructure, and sharing services. The questionnaire (survey) was available both physically and digitally at the mobility hub. For the pass-by users, the QR code was also available within the hub, for people who stayed longer, survey sheets and a box to deposit them were available on-site. The survey targeted all types of users (regular users, less frequent, students, residents, etc.).

Before presenting those concrete survey results, it is relevant to show who participated in the survey. The answers from 30 users were collected, Figure 20 indicates that 65,2% of the respondents are between 22-25 years. The participation of women and men was 50% and 47%, respectively. Unfortunately, no person identified as non-binary or diverse took part in the survey. Moreover, most respondents had at least a bachelor's degree, while the distribution of master's degree holders and people who do not hold a degree was the same (Figure 21). More than 30% were residents from the areas, while 5 participants lived outside Munich. Regarding the use of the mobility hub, 90% of the answers indicate that the primary use was not for mobility purposes but mainly used the space as a place to stay. Still, 36% of the people did use the various provided mobility services, as shown in Figure 22.

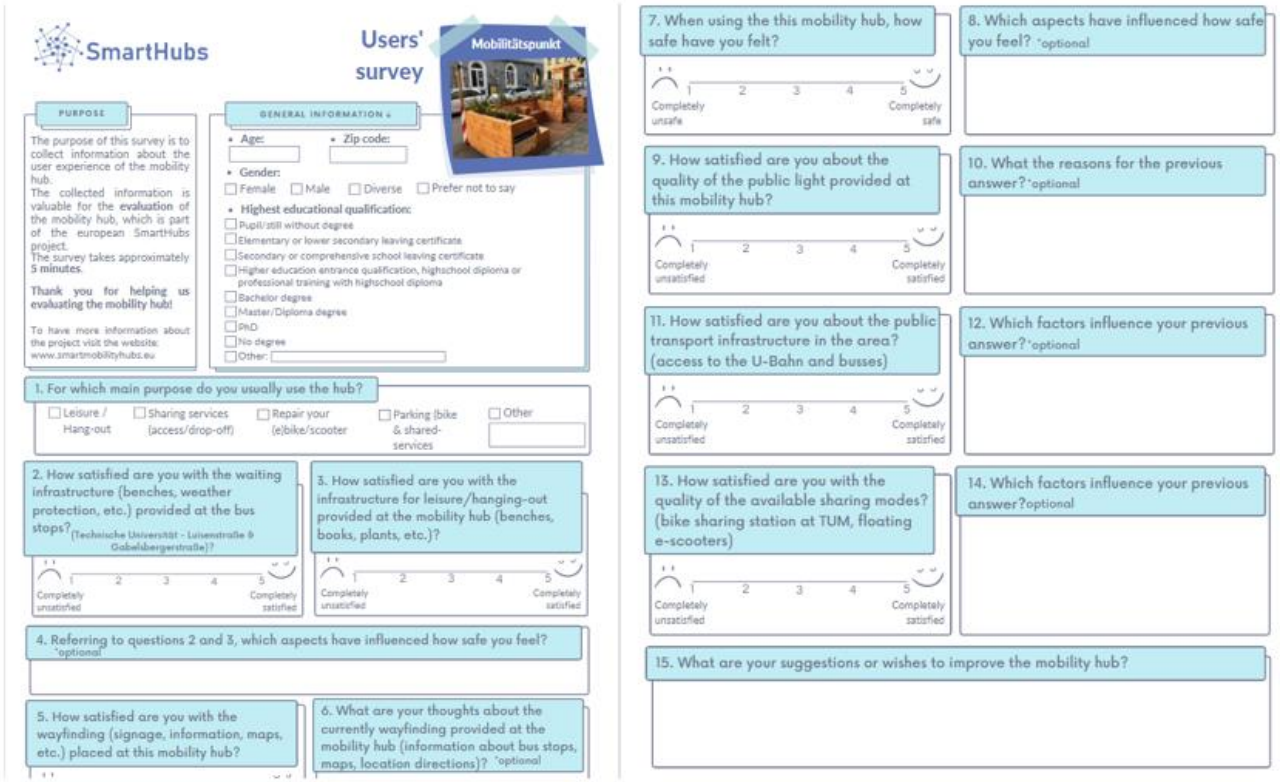

Figure 19. On-site survey

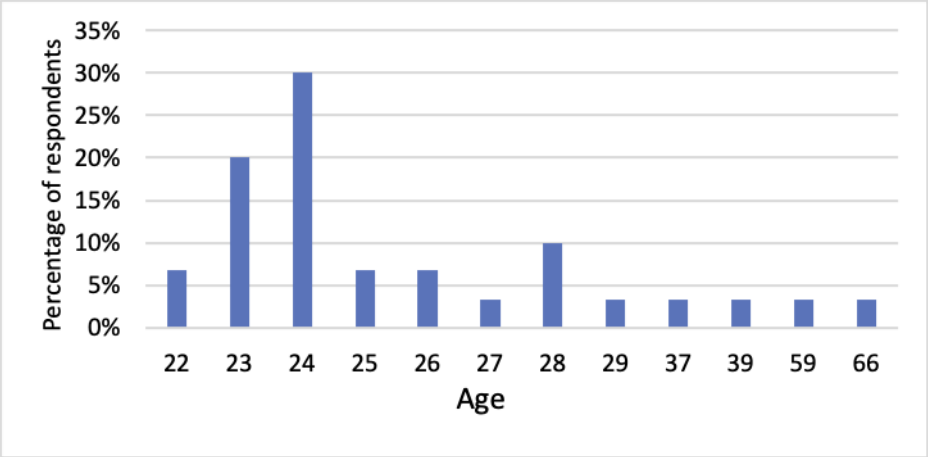

Figure 20. Age distribution of the respondents

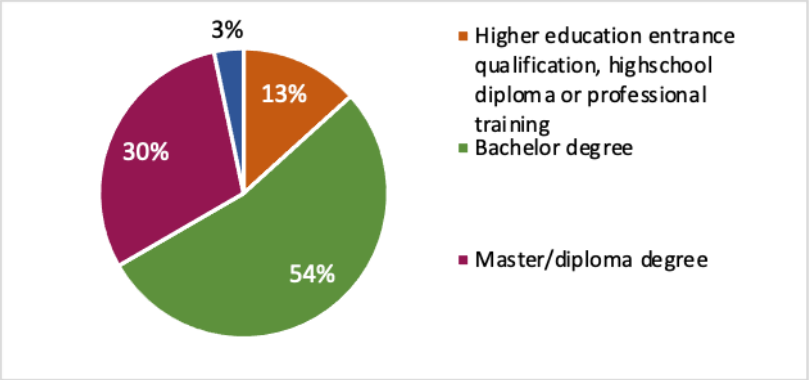

Figure 21. Respondents' educational qualification

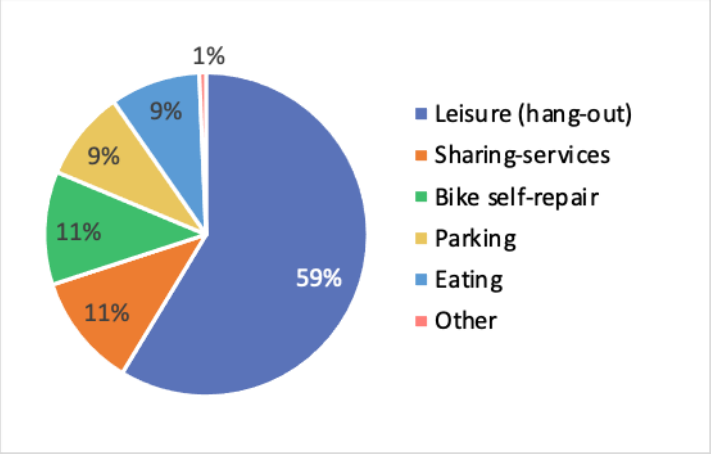

Figure 22. How did people used the mobility hub?

To assess the users' satisfaction with the waiting infrastructure, the survey addressed both the infrastructure provided at the mobility hub and at the public transport stops. It is important to highlight this distinction since the public infrastructure was beyond the project's scope. Figure 23 presents the answers to both questions, revealing a significantly more positive perception of the mobility hubs infrastructure in contrast with the current conditions of the bus stops. According to the respondents' comments, bus stations were described as boring and lacking weather protection. Some additional comments highlighted the presence of green elements (plants), flexible seating opportunities, and the different uses offered by the mobility hub. Others mentioned that charging options, even more plants, and more space were missing. The results concerning the wayfinding elements implemented in the living lab also reflect positive opinions from users,
Figure 24.A. Even though not all respondents provided insight, some emphasized the quality of the materials used and the inclusion of information for wheelchair users. Nonetheless, other respondents argued it was not the most relevant feature of the hub.

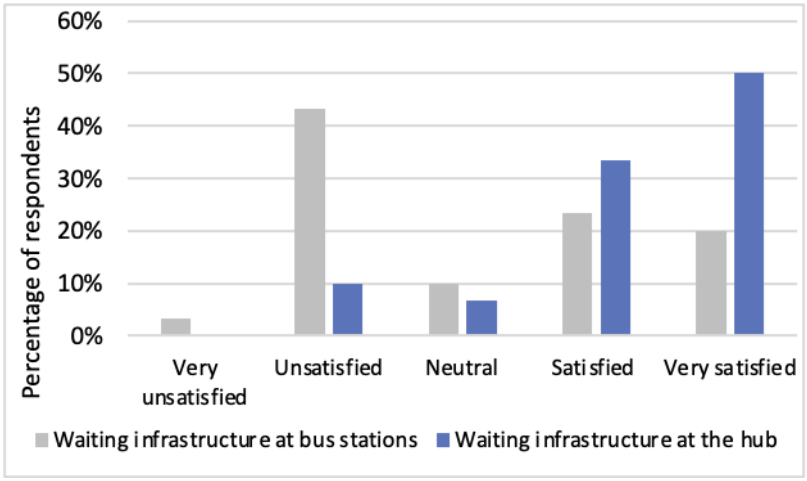

Figure 23. Users' satisfaction regarding the waiting infrastructure

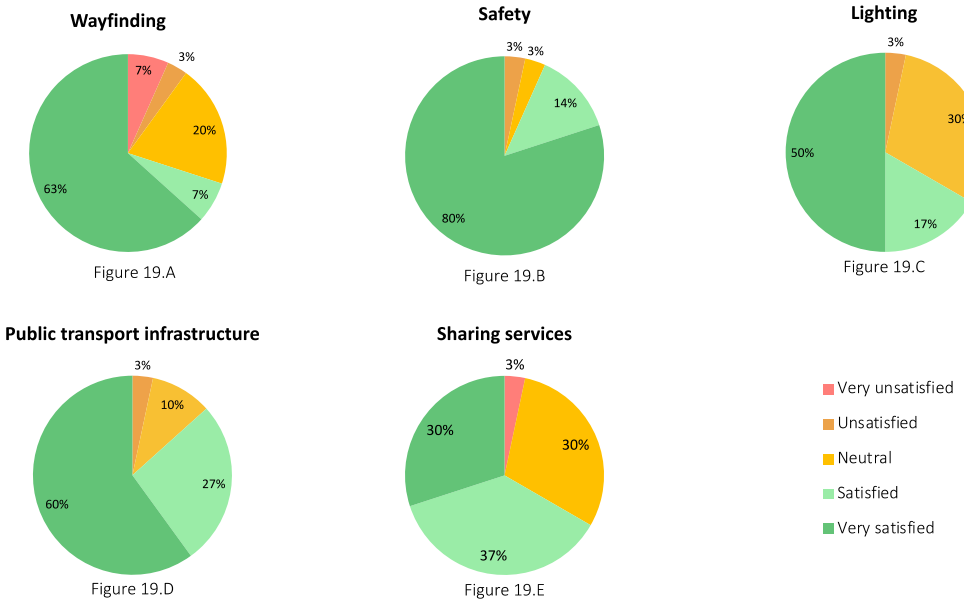

Figure 24. User's perceptions of the different evaluated aspects

Another relevant KPI is how safe and secure the users of the mobility hub felt when using the amenities. As illustrated in
Figure 24.B , most respondents were pleased with the safety conditions at the hub. Most answers were also positive, the following statements related to the calm character of the area, the low traffic on the street, the material of the infrastructure, and the cleanliness. The pleasing lighting conditions also enhance the safety feeling. Precisely, the level of satisfaction concerning the lighting conditions was also part of the evaluation (see
Figure 24.C). The main driver for the positive perception was the addition of "cozy" lights to enhance the atmosphere of the place, which, in addition to the street lighting, provided better conditions. Moreover, other participants indicated using the hub during the day.

The last questions referred to the public transport service and offered shared modes. Although these elements were not directly under control of the team, it was relevant to collect information about it. First,
Figure 24.D shows the users' answers concerning the public transport infrastructure in the area. According to the provided explanations, the main reason was the proximity to the bus and subway services. While the results are more divided regarding the sharing modes options, as
Figure 24.E shows. The comments with negative connotations related to the infrequent availability in the area and uncertainty about the availability at the hub. However, other respondents consider the opposite and indicated that bike-sharing options can always be found in the surroundings.

Finally, the users were consulted about their suggestions and wishes to improve the mobility hub. The answers below not only demonstrate that the living lab was well received but also expose the potential improvements. The latter mainly relate to supporting elements (like the trash bin), expanding the hub for more parking and space for sharing options, and the possibility of making it permanent.

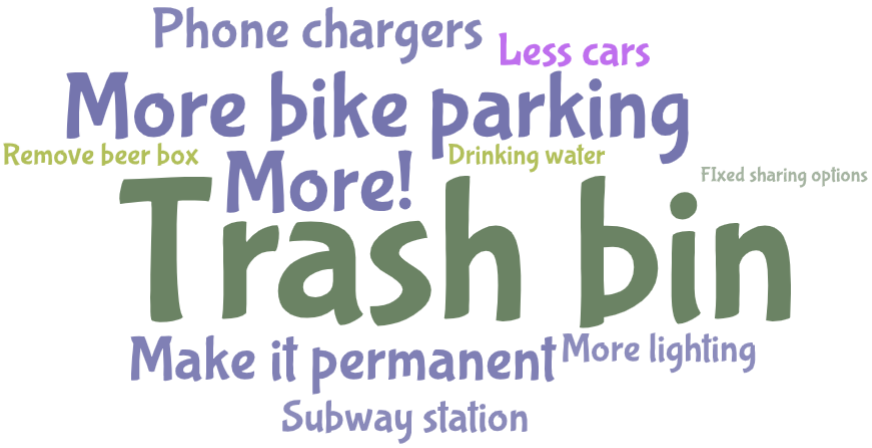

Figure 25. Additional aspects the users wished for the mobility hub.

4.2.On-site workshop to identify potential improvements of the hub

To complement the former results, an onsite workshop was conducted with users of the hub. The goal was to identify additional elements the people found attractive and which aspects they did not like. The participants were encouraged to write down their thoughts and place them on a board, as depicted in Figure 26. Regarding their wishes, the responses from these participants aligned with the main aspects identified in the survey (i.e., trash bin, more space for seating, more parking spaces). Additionally, respondents repeatedly mentioned the lack of weather protection infrastructure, folding chairs, and charging options for bicycles. Positive aspects mentioned included the aesthetic design, the "cozy" lights, the protection it offers from the street, and how it invites people of all ages to enjoy. The provision of an attractive place to stay was also emphasized.

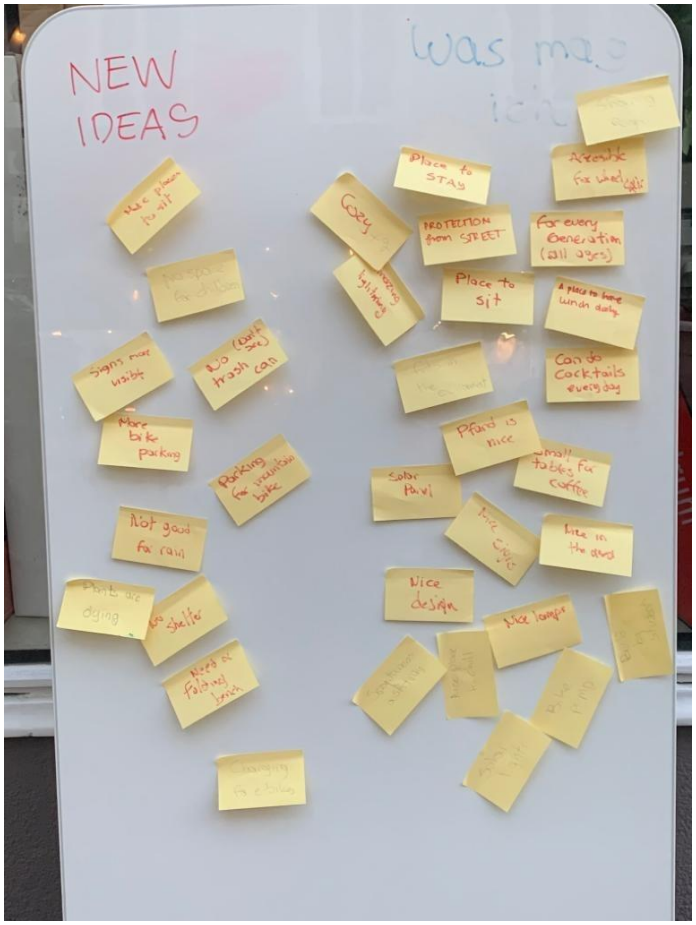

Figure 26. Results of the on-site workshop

4.3.Stakeholders' interviews

This section presents the most relevant aspects discussed with practitioners form the mobility department of the city of Munich and the public transport operator MVV. Their feedback has been sorted out based on 3 main categories.

1. Potential applications of the general planning/design approach

During the session, the stakeholders received a brief explanation of the overall planning and design approach of the SmartHubs project to implement mobility hubs. They mentioned that currently various administrative stakeholders, like municipalities, who are working in the field, need concrete information and results that can convince them to develop a mobility hub in a specific area. In this sense, the macro-micro approach proposed by this living lab to identify potential locations (SmartHubs Deliverable 3.1) has the potential to be used for this purpose, allowing it to adapt to the needs or goals of the decision makers (e.g., filling a public transport gap or as a connector).

Regarding the implementation of future mobility hubs, the stakeholders from the public transport operator MVV agreed with the approach taken by the living lab of reusing existing infrastructure. They provided a potential location where this might be feasible: Garching. In this area, there is already a mobility hub without naming it so. They also added in this case, as well as in other future cases, it would be useful and interesting to apply co-design approaches like the game created by the living lab to enhance engagement and acceptance from the citizens. This is especially important when dealing with parking space modification/removal.

Another important point mentioned indicated that the municipalities do not wish or have the time to be involved in the design process. Instead, they prefer a concrete "product" that clearly indicates where, why, and how should a mobility hub be implemented. In other words, ideally, they would just allocate the funds. In line with, both experts agreed that the City of Munich would be the most suitable entity to contact for the implementation of the living lab approach.

2. Administrative barriers/limitations for the planning/design approach

One of the main comments from the experts pertained to the need to find a way of bringing together all the projects/entities working on mobility hubs to share ideas and bring them together. However, they also acknowledged the difficulties of the process. In this regard, they mentioned the role of DB Smart City. Moreover, it was noted that, while not an absolute limitation, for a project to be considered an official "Mobilitätspunkt", it must include an information pole with specific minimum quality requirements.

3. Munich's Living Lab implementation

The stakeholders valued giving the streets back to the people and reducing private parking reduction. However, for bigger and permanent projects, it might be more difficult as car-sharing spaces must be taken into account. At this point, also comes into question the problem with space availability in the city. The practitioners also mentioned the need to include more transport opportunities and the relevance of finding locations offering enough mobility options. Still, the added value of public space was recognized.

Regarding the evaluation, both stakeholders recommended focusing more on behavioral changes after the implementation. This approach can also be used to engage to developers for future projects. Lastly, concerning the implementation of the parklet/mobility hub, they stated that maintenance tasks and complaints from neighbors are the main barriers and challenges associated with this type of approach to create mobility hubs. Yet, they added that participative approaches (such as games and co-implementation) can contribute to fostering commitment and acceptance. They also saw the value of involving local business owners.

4.4. SIS: Multi-criteria and multi-actor appraisal

"SIS is a participatory appraisal method to quantify the negative and positive impacts of projects on stakeholders, based on the assumption that impact is the product of 'objective' observations or estimations (by experts), and 'subjective' value judgements (by stakeholders)" (Te Boveldt et al. 2022). The output are the impacts of the hub on the interests (evaluation criteria) for the stakeholders (different actors that will be influenced or influence the mobility hubs, e.g. the city, transit operator, practitioners, citizens) to consider in mobility hubs. For this approach, we summarized the results of the evaluations of the citizens, the representatives from the city of Munich, and the representatives of the public transport operator in Munich. After conducting workshops with these stakeholders, we incorporated their primary interests as criteria (see Table 3). In a subsequent round, we requested representatives of these stakeholders to rank the criteria on a scale from 0 (not important at all) to 6 (very important) (referred as "Value" in Table 3). As requirement of the tool, these values were converted in a scale from 0 to 10 (referred as "Converted Value" in Table 3). In the case of citizens, 10 individuals with diverse social backgrounds (age, gender, income, education, occupation, migration background) were asked to rate the criteria. Table 4 indicates the scores subjectively assigned by the living lab leaders to each criterion based on their expertise, the characteristics of the hub, and the different qualitative evaluation processes. The score represents the impact that the hub has on each criterion for the different stakeholders.

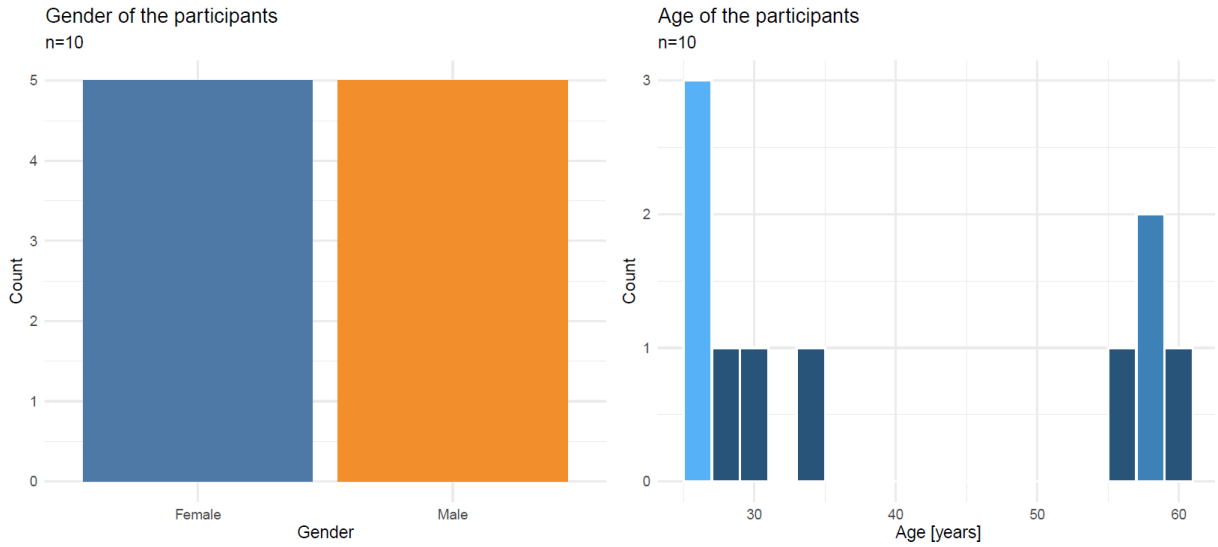

Figure 27. Gender and age of the participants that grade the criteria (n=10)

Table 3. Criteria per stakeholder and converted value in a scale from 0 to 10

Criteria (City of Munich)	Value	Converted value
The hub as a place to stay	0	0.0
Multiple sustainable mobility options	6	10.0
Sustainable and durable materials	1	1.7
Information (e.g. pole, directions, schedules, etc.)	4	6.7
Visibility	5	8.3
Integration with other mobility hubs	2	3.3
Digital integration	3	5.0
User friendly (simple to use)	6	10.0
Criteria (Public transport planner)	**Value**	**Converted value**
The hub as a place to stay	2	3.3
Multiple sustainable mobility options	6	10.0
Proximity to Public transport stop	4	6.7
Information (e.g. pole, directions, schedules, etc.)	5	8.3
Visibility	5	8.3
Well maintained (clean, low noise)	4	6.7
Criteria (Citizens)	**Value**	**Converted value**
Sustainable mobility options	6	10.0
Other activities than mobility	4	6.7
A design that is both cozy and sustainable,	3.5	5.8
Inclusive design and information	3	5.0
Safe, quiet and clean	3	5.0

Table 4. Score of each criterion used in SIS

Criteria	Score (compared to doing nothing)
The hub as a place to stay	Positive (0.67)
Multiple sustainable mobility options	Slightly positive (0.33)
Sustainable and durable materials	Positive (0.67)
Information (e.g., pole, directions, schedules, etc.)	Slightly positive (0.33)
Visibility	Slightly positive (0.33)
Integration with other mobility hubs	Strongly Negative (-0.67)
Digital integration	Neutral (0)
User friendly (simple to use)	Positive (0.67)
Proximity to Public transport stop	Neutral (0)
Well maintained (clean, low noise)	Slightly negative (-0.33)
A design that is both cozy and sustainable,	Most positive (1)
Inclusive design and information	Slightly positive (0.33)
Safe, quiet and clean	Slightly negative (-0.33)

The appraisal tool revealed that the hub has significantly more beneficial impacts than negative ones (Figure 28). Another output is that the hub is more in line with the interests of citizens, followed by the mobility department of the city of Munich, and finally the public transport operator. Some negative aspects (Figure 29) considered by the citizens include the slight increase in

noise due to people gathering at the hub, while for the city of Munich, the hub's location outside the network of hubs in the city is a drawback, and for the public transport operator, the fact that the hub is not directly located at a public transport station is a challenge. On the positive side (Figure 29), the most relevant impacts for citizens are the multiple mobility services, the various other activities that can be performed at the hub, and the cozy design. The city of Munich considers the benefits from the multiple services offered at the hub and its ease of use, while the public transport operator appreciates the multiple services, the visibility, and the information provided at the hub.

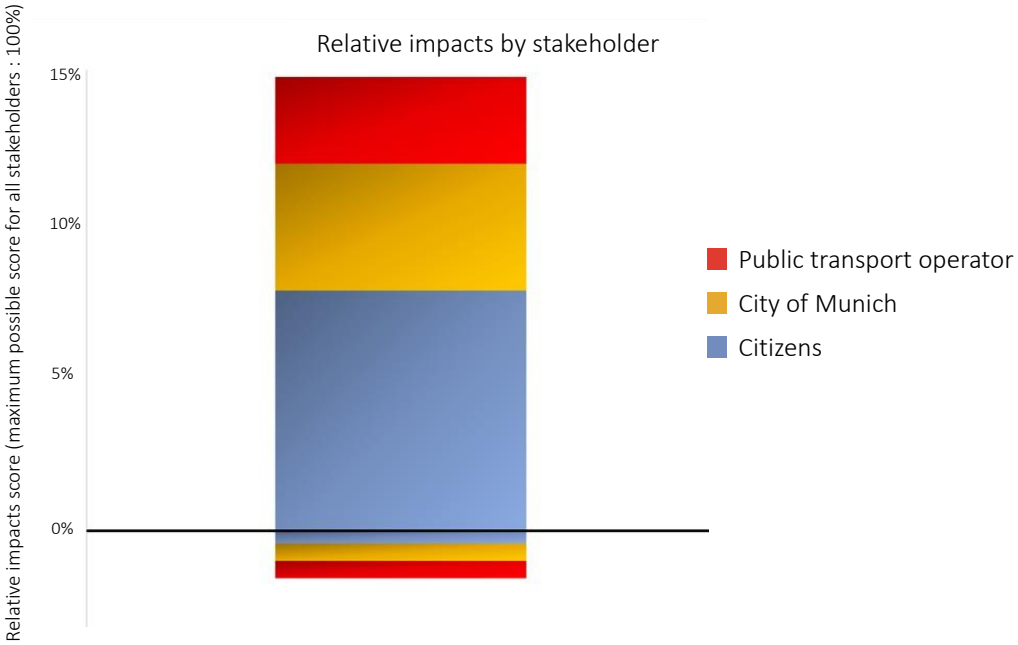

Figure 28. Relative impact of the criteria by stakeholder

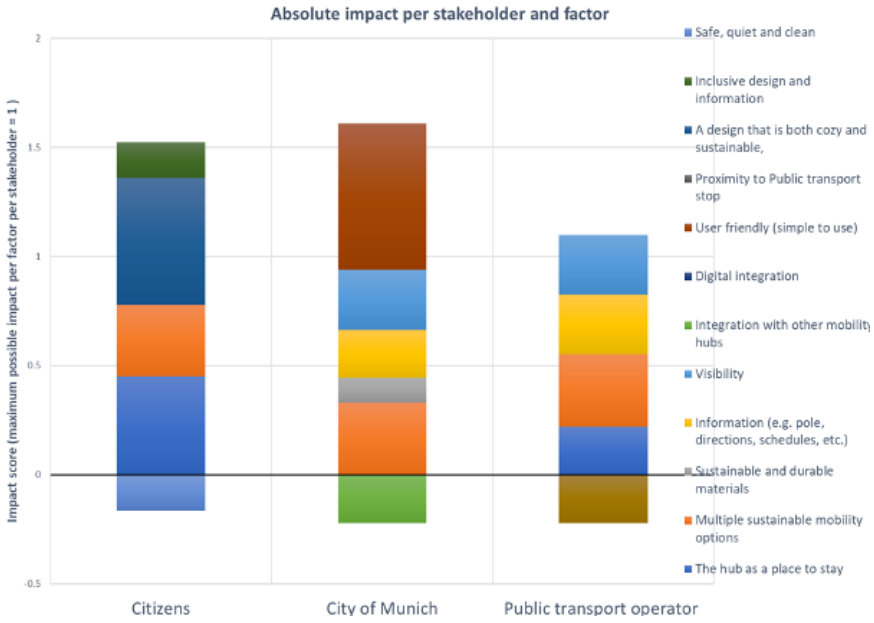

Figure 29. Absolute impact of the criteria by stakeholders

5. CONCLUSIONS

The Munich living lab aims to co-design and implement a mobility hub in the surroundings of the Technical University of Munich. The main goal was to promote active and shared modes of transportation, foster a sense of community, and create a more livable environment. To determine the citizens' needs, three approaches were taken: an on-street panel, a co-creation game, and a survey, which showed the mobility hub should include bike parking, seating, e-scooter parking, wayfinding, inclusive information, urban garden, cafes, and kiosks. Users gave positive feedback on the quality of facilities. Most respondents were pleased with safety conditions and lighting, while comments suggested adding more plants, charging options, and more space (extending the hub). Stakeholders agreed on reusing existing infrastructure for future mobility hubs, applying co-design approaches to enhance engagement and acceptance from citizens, and focusing more on behavioral changes after implementation. Lastly, the SIS participatory appraisal method quantified the negative and positive impacts of the project on stakeholders, showing the hub has more positive impacts than negative ones and is more in line with the interests of citizens, the mobility department of the city of Munich, and the public transport operator.

It is important to highlight that multiple approaches were considered for the design and evaluation of the hub. Workshops, such as the implemented game sessions, showed active participation and interest from the participants. However, conducting the survey and short questionannaire proved to be more challenging as people did not show significant interest in taking part. For future similar applications, it is recommended to organize activities that attract users or potential users to participate in the surveys. Offering rewards after participation is also a suggested approach.
The exchange with stakeholders from the planning and service provision sector was fruitful and valuable in informing the design and implementation approach followed by this Living Lab, as well as gathering information about the relevant criteria for stakeholders.

6. REFERENCES

Aono, S. (2019). *Identifying Best Practices for Mobility Hubs* (Technical Report, UBC Sustainability Scholar.). Translink.

Belz, J., Brand, T., Eggs, J., Ermes, B., Follmer, R., Gruschwitz, D., Kellerhoff, J., Pirsig, T., & Roggendorf, M. (2020). *Mobilität in Deutschland—MiD Regionalbericht Stadt München, Münchner Umland und MVV-Verbundraum. Studie von infas, DLR, IVT und infas 360 im Auftrag des Bundesministeriums für Verkehr und digitale Infrastruktur*. Bundesministeriums für Verkehr und digitale Infrastruktur. https://www.mvv-muenchen.de/fileadmin/mediapool/downloads/infas_GrossraumMuenchen_Regionalbericht_MiD5431_20201204.pdf

Bogren, L., Fallman, D., & Henje, C. (n.d.). *User-centered Inclusive Design: Making Public Transport Accessible*. 6.

CoMoUK. (2019). *Mobility Hubs Guidance*. https://como.org.uk/wp-content/uploads/2019/10/Mobility-Hub-Guide-241019-final.pdf

Duran-Rodas, D., Navarro Avalos, F., Hall, J., Nichols, A., Büttner, B., Baguet, J., & Susilo, Y. (2022). *Guidelines for the integration of mobility hubs into the urban space* (Deliverable D 3.1; Smart Mobility Hubs as Game Changers in Transport). https://www.smartmobilityhubs.eu/data

Geurs, K., & Münzel, K. (2022). *A multidimensional mobility hub typology and inventory. SmarHubs Project.* https://www.smartmobilityhubs.eu/data

Johansson, M., Bramryd, T., Glotz-Richter, M., & Lars-Ove, K. (2021). *A Planner's Guide to the Shared Mobility Galaxy*. (Rebecca Karbaumer and Friso Metz). SHARE-North Academy. https://share-north.eu/wp-content/uploads/2022/05/Shared-Mobility-Guide_ENGLISH.pdf

Klanke, P. (2022). *What are the Needs and Expectations Towards a Smart Mobility Hub? A Mixed-Methods Case Study in Munich*. Technical University of Munich.

Landeshauptstadt München. (2023). *Mobilitätsstationen*. München Unterwegs. https://muenchenunterwegs.de/angebote/mobilitaetsstationen#:~:text=Die%20vom%20Stadtrat%20am%2019,2026%20in%20ganz%20M%C3%BCnchen%20vor.

Landeshauptstadt München - Mobilitätsreferat. (n.d.). *Mobilitätsstrategie 2035*. München Unterwegs. https://muenchenunterwegs.de/2035

Metrolinx. (2011). *Mobility Hub Guidelines—For the Greater Toronto and Hamilton Area*. Government of Ontario. http://www.metrolinx.com/en/docs/pdf/board_agenda/20110218/MobilityHubGuidelines_optimized.pdf

Miramontes, M. (2018). *Assessment of mobility stations. Success factors and contributions to sustainable urban mobility.* [PhD. Dissertation, Technical University of Munich]. https://www.researchgate.net/publication/329758572_Assessment_of_mobility_stations_Success_factors_and_contributions_to_sustainable_urban_mobility

Mobilitätsstationen im MVV. (2023). MVV. https://www.mvv-muenchen.de/mobilitaetsangebote/mobilitaetsstationen/index.html

Monzón, A., Hernández, S., & Ciommo, F. D. (2016). Efficient Urban Interchanges: The City-HUB Model. *Transportation Research Procedia*, *14*, 1124–1133. https://doi.org/10.1016/j.trpro.2016.05.183

muenchen.de. (2022, January 20). *Ausbau von Shared-Mobility-Angeboten beschlossen*. Landeshauptstadt München. https://ru.muenchen.de/2022/13/Ausbau-von-Shared-Mobility-Angeboten-beschlossen-99599

Nobis, C., & Kuhnimhof, T. (2018). *Mobilität in Deutschland—MiD Ergebnisbericht Studie con infas, DLR, IVT und infas 360 im Auftrag des Bundesministers für Verkehr und digitale Infrastruktur* ((FE-Nr. 70.904/15)). https://www.mobilitaet-in-deutschland.de/pdf/MiD2017_Ergebnisbericht.pdf

Nybacka, M., & Osvalder, A.-L. (2019). Inclusive Design Strategies to Enhance Inclusivity for All in Public Transportation—A Case Study on a Railway Station. In S. Bagnara, R. Tartaglia, S. Albolino, T. Alexander, & Y. Fujita (Eds.), *Proceedings of the 20th Congress of the International Ergonomics Association (IEA 2018)* (Vol. 824, pp. 1689–1698). Springer International Publishing. https://doi.org/10.1007/978-3-319-96071-5_173

Ongel, A., Cornet, H., Kong, P., Khoo, R., Liu, T., & Kloeppel, M. (2018). Public Transport Service Quality Improvement Using Universal Design Standards and Advanced Vehicle Technologies. *2018 International Conference on Intelligent Autonomous Systems (ICoIAS)*, 211–216. https://doi.org/10.1109/ICoIAS.2018.8494057

Pappers, J., Martinez-Ramirez, L., & Imre, K. (2022). *Synthesis of KPIs to evaluate mobility hubs* (Deliverable D 2.2; Smart Mobility Hubs as Game Changers in Transport). https://www.smartmobilityhubs.eu/data

Rzehak, P. (2022). *Demografie der Münchner Bevölkerung 2021 Auswertungen zum Bevölkerungsbestand und zu Bevölkerungsbewegungen*. Statistisches Amt der Landeshauptstadt München. https://stadt.muenchen.de/dam/jcr:0e15dad6-a549-46c6-8695-b5a7116cd976/mb220101.pdf

Schemel, S., Niedenhoff, C., Ranft, G., Schnurr, M., & Sobiech, C. (2020). *Mobility Hubs of the Future—Towards a new mobility behaviour*. ARUP/RISE. https://www.ri.se/sites/default/files/2020-12/RISE-Arup_Mobility_hubs_report_FINAL.pdf

Statistisches Amt München. (2022). *Statistische Daten zur Münchner Bevölkerung*. https://stadt.muenchen.de/infos/statistik-bevoelkerung.html

The 7 Principles | Centre for Excellence in Universal Design. (n.d.). Retrieved 31 August 2022, from https://universaldesign.ie/What-is-Universal-Design/The-7-Principles/

Urban Design Studio. (2016). *Mobility Hubs: A Reader's Guide.* Urban Design Studio. http://www.urbandesignla.com/resources/MobilityHubsReadersGuide.php

Te Boveldt, G., Keseru, I., & Macharis, C. (2022). When monetarisation and ranking are not appropriate. A novel stakeholder-based appraisal method. Transportation Research Part A: Policy and Practice, 156, 192-205.