Pontifícia Universidade Católica
do Rio de Janeiro

Raquel Corrêa Cordeiro

Towards Smarter Cities:

Strategies to integrate quantitative and qualitative data by participatory design process

Doctoral thesis

Thesis presented to the Graduate Program in Design at PUC-Rio in partial fulfillment of the requirements for obtaining a degree of Doutora em Design.

Advisor: Prof. Maria Manuela Rupp Quaresma

Rio de Janeiro,
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Abstract

Cordeiro, Raquel Corrêa; Quaresma, Manuela (Advisor).
Towards Smarter Cities: Strategies to integrate quantitative and qualitative data by participatory design process. Rio de Janeiro, 2024. 212p. Tese de Doutorado - Departamento de Arte & Design, Pontifícia Universidade Católica do Rio de Janeiro.

The concept of smart cities is often associated with technological advancement, but it also encompasses aspects of citizen well-being and sustainability. The growing availability of digital data results in an excessive focus on technology, neglecting citizen participation and consequently underutilizing the potential of this information. Our hypothesis is that design can facilitate access to complex urban data through data storytelling and participatory processes. Therefore, we tested a co-design process using mixed methods to analyze mobility behavior. Structured in two phases, the study initially explored mobility projects by analyzing reports from the Civitas initiative and interviewing professionals in the field. The identified challenges and solutions were then tested in the second phase, employing data collection methods such as city open data analysis, diary studies, and sentiment analysis on social media. Finally, a co-design workshop was conducted incorporating data visualization tools to co-analyze the weather effects on urban mobility. The results highlight the significant potential of the designer as a facilitator, with participants reporting ease in analyzing substantial data volumes and considering the proposal innovative and enjoyable. Future research may evaluate participants' understanding of the data. The contribution of this thesis lies in a co-design process that can involve various stakeholders, including government, private enterprises, and citizens, using data storytelling tools applicable to any project dealing with large data volumes.

Keywords

Smart City; Big Data; Citizen Participation; Human-Centered Design; Urban Mobility;

Resumo

Cordeiro, Raquel Corrêa; Quaresma, Maria Manuela. **Rumo a cidades mais inteligentes: Estratégias para integrar dados quantitativos e qualitativos por meio de processos de design participativo.** Rio de Janeiro, 2024. 212p. Tese de Doutorado - Departamento de Arte & Design, Pontifícia Universidade Católica do Rio de Janeiro.

O conceito de cidades inteligentes é frequentemente associado a avanços tecnológicos, porém também abrange aspectos do bem-estar dos cidadãos e a sustentabilidade. A crescente disponibilidade de dados digitais resulta em um foco excessivo na tecnologia, negligenciando a participação cidadã e subutilizado consequentemente o potencial dessas informações. A nossa hipótese é que o design pode facilitar o acesso a dados urbanos complexos por meio de narrativas baseadas em dados e de processos participativos com a população. Logo, testamos um processo de co-design utilizando métodos mistos para analisar o comportamento de mobilidade. Estruturada em duas fases, a pesquisa inicialmente explorou projetos de mobilidade, analisando relatórios da iniciativa Civitas e entrevistando profissionais atuantes na área. Os desafios e soluções identificados foram testados na segunda fase, usando métodos como coleta de dados abertos municipais, diário de uso e análise de sentimentos em redes sociais. Por fim, foi realizado um workshop de co-design usando ferramentas de visualização de dados para co-analisar a relação dos efeitos meteorológicos na mobilidade urbana. Os resultados destacam o potencial do designer como mediador, com participantes relatando facilidade para analisar volumes substanciais de dados e considerando a proposta inovadora e agradável. Pesquisas futuras poderiam avaliar a compreensão dos dados pelos participantes. A contribuição desta tese reside em um processo de co-design que pode incluir diversos atores, como governo, setor privado e cidadãos, utilizando ferramentas de narrativas baseadas em dados, aplicáveis a quaisquer projetos com vasto volume de informação.

Palavras-chave

Cidades Inteligentes; *Big Data*; Participação Cidadã; Design Centrado no Humano; Mobilidade Urbana;

Table of contents

List of figures

List of tables

List of charts

1
Introduction

In an increasingly connected world, the emergence of smart cities is a notable trend (Cathelat, 2019). However, this concept extends beyond merely enhancing technological infrastructure; it encompasses sustainability and citizen well-being (OECD, 2020). The surge in available data provides a valuable resource for public administration, which, when coupled with qualitative research and citizen participation, could be more effectively utilized (Kitchin, 2013).

While society has historically used information to make decisions, the contemporary era witnesses a significant increase in the volume of high-quality data, thanks to reduced complexity and improved access to new technologies (Allam and Dhunny, 2019). According to the International Data Corporation, the quantity of new data is projected to grow from 33 trillion gigabytes in 2018 to 175 trillion gigabytes by 2025 (Reinsel, Gantz and Rydning, 2018). Technological advancements have outpaced practical applications, resulting in vast amounts of underutilized data (Bass and Old, 2020). As highlighted by Barkham, Bokhari and Saiz (2018), the utilization of urban data is still in its early stages but represents a global movement. The challenge lies in harnessing this wealth of data for widespread application (Kitchin and Lauriault, 2015).

This underutilization becomes especially poignant when juxtaposed with the urgent need for informed decision-making to address the consequences of climate change. According to IPCC (2021), climate change is a phenomenon that demands crucial attention due to its numerous consequences on affected cities. The frequency of extreme natural events is increasing, which directly impacts the population. As a result, the group warned that changes in human behavior are necessary to mitigate temperature increases. For them, urban planning must consider the uncertainties that are exacerbated by this crisis and adapt to its consequences.

Addressing this behavioral shift requires an approach that integrates technological data with citizen participation, providing a human perspective on city life (IPCC, 2022). This integration enriches analysis, contextualizing data and offering solutions that transform attitudes into more sustainable routines. Despite

the connectivity of smart cities and data capture, there is still a gap in intelligent utilization (Kitchin, 2015). Effectively managed data, coupled with other indicators, could facilitate urban management (Kitchin, Lauriault and McArdle, 2015).

Combining data management with citizen-centered projects can inform public policies to enhance service experiences. In this context, innovation labs play a crucial role as environments where design methodologies could be explored to tackle challenges within the public sector and to implement the solutions identified through research (Ferreira, 2019). This thesis focused on citizen experience, meaning the experience of citizens interacting with public services.

Mobility is central to discussions on creating more user-friendly cities. An example illustrating the importance of citizen involvement in urban policies is the reduction of speed limits on highways in São Paulo in 2015. Mathematical models supported the idea that higher speeds contribute to increased traffic congestion and accidents (Afukaar, 2003; Bellomo, Delitala and Coscia, 2002). The reduction in São Paulo led to a 10% decrease in congestion and a 35% decrease in accidents. However, despite positive results, a significant portion of the population rejected the speed reduction policy, which was ultimately reversed by the subsequent mayor. Understanding different groups' goals and effective communication are essential for building urban models and implementing public policies (Cordeiro, Cordeiro and Quaresma, 2021).

The failure of communication was central to the disagreement. Generic messages attempting to reach everyone effectively reached only a few, particularly when trying to impact deeply ingrained attitudes (Frascara, 2000). The disagreement in São Paulo led to political opposition later exploited in municipal election campaigns. A co-design approach could be useful for integrating big data and citizen participation in smart urban mobility.

A co-design process can open a dialogue with various stakeholders, engaging and empowering citizens to change their relationship with the city (Mulder, 2015a). Therefore, this research aims to explore the use of big data and citizen participation in smart cities, believing that this integration can foster changes toward more sustainable behaviors—a crucial aspect of the current climate emergency.

Central to citizen-centric design is the engagement of citizens, stakeholders, and experts, ensuring a diverse array of perspectives are considered (Dittmar *et al.*, 2021). In acknowledging the global challenges, the design discipline has the

potential to synthesize diverse insights through compelling storytelling, and enriching participatory processes (Design Council, 2021). By involving the community in data-driven narratives, the relevance and impact of design solutions can be significantly enhanced (Dykes, 2020).

The research problem under investigation focuses on the insufficient access and utilization of mixed data, which encompasses various types like qualitative and quantitative data. D'Ignazio and Bhargava (2018) recognize that data is a currency of power, but the ability to derive meaning from it is unevenly distributed in contemporary society. The authors propose that making data understandable for the general population requires engaging learners with hands-on creative activities tailored to their current knowledge. Without such invitations, attempts to work with novices might deviate into a techno-centric focus on acquiring software skills, lacking the potential to connect learners with the opportunities that data presents in achieving their goals.

The underutilization of extensive mixed urban data emerges as a challenge, prompting a closer examination of methods to gather and collaboratively analyze data. According to Meroni and Selloni (2022), emerging digital tools show promise for participatory techniques. Despite their potential, the authors caution that there is a gap in understanding the full scope of these tools, emphasizing the need for thorough evaluation. The integration of advanced data visualization tools emerges as a solution to ensure transparency and comprehensibility in conveying complex information (D'Ignazio and Bhargava, 2018).

Research in design and human-computer interaction, such as this thesis, combines technological solutions with social integration, aiming to understand how technology can be integrated into social contexts and meet human needs. Such research acknowledges the importance of considering personal motivations for behavioral changes, as highlighted by Wendel (2013). Moreover, the climate crisis urgently requires a multidisciplinary approach, and design could serve as a bridge that connects society, academia, and government (Wrigley, 2016). This underscores the designers' role in collaborating across disciplines, leveraging their expertise to develop solutions that engage diverse stakeholders and drive meaningful change.

Giaccardi and Redström (2020) argue that to navigate these complex futures, we must reframe our design theories and methodologies to embrace new paradigms, moving beyond the limitations of human-centered design. For them, we must

acknowledge the increasing presence of algorithms, diverse forms of intelligence, and various life forms in design practices, treating them as collaborators in a more-than-human design approach. The authors characterize this approach as one where design considers outcomes that result from the dynamic interplay between individuals and networked computational elements. This landscape introduces a heightened level of uncertainty, where the convergence of diverse elements forms a complex and fluid environment of possibilities and performances. This convergence is not a controllable process that we prototype in a conventional sense; rather, it is something we cultivate, nurture, and nourish.

With this more-than-human perspective, we believe that the design process holds the potential to engage with the intricacies of the contemporary world. It goes beyond being a mere translator and maker, but also adapting to the constant technological changes. Through iterative refinement of the process, we can bring a human perspective to a time of uncertainty.

So, our overall **objective** is to test a co-design process using mixed methods to analyze mobility behavior. This encompasses defining concepts of big data, smart cities, and citizen participation, identifying challenges and solutions in projects involving digital data and citizen participation, exploring the integration of citizen experience with urban data, and testing the use of mixed data with a participatory design process (Table 1).

The thesis methodology is divided into two phases: a project exploration in the first phase and a testing data collection and analysis in the second phase. The initial phase implied studying mobility projects using citizen data, through a content analysis of reports from the Civitas initiative of the European Union[1]. The methodology of this study is extensively detailed in subchapter 4.1.1. Subsequently, interviews were conducted with professionals involved in projects combining citizen input and urban data, as outlined in subsection 4.2.1. The challenges and solutions identified in these two studies were then explored and tested in the second phase.

The subsequent research techniques were explanatory. Initially, we collected various data on Rio de Janeiro's mobility and weather conditions. We analyzed the

[1] CIVITAS is a program aimed at assisting the European Commission in accomplishing its mobility and transport objectives. For further information, visit the website: https://civitas.eu/

usability of the DataRio[2] website, the municipality's open data portal, with a series of contextual interviews (5.1.1). We conducted qualitative research, specifically a diary study, to identify citizen experiences with each mode of transportation, detailed in subsection 5.2.1. We combined these data with posts from social media, extracting them to identify associations and sentiments of the population, as elaborated in subsection 5.3.1. Finally, we facilitated a co-design workshop, with different participants analyzing the identified problems and proposing solutions for mobility improvements, as described in subsection 6.1.

Based on the findings, we propose a process that integrates quantitative and qualitative data using urban data visualization in co-design workshops. Additionally, insights were generated for urban mobility, considering the implications of climate change.

	Chapters	Objectives	Methods		Description
I - EXPLORATORY	2 and 3	**To define** concepts of big data, smart city, and citizen participation		Literature review	Researching books and articles on the thesis topics
	4	**To identify** challenges and solutions in projects with big data and citizen participation	4.1	Reference cases	Analyzing content from project reports of the Civitas initiative
			4.2	Interviews	Conducting interviews with professionals working on urban data and citizen participation
II - EXPLANATORY	5	**To explore** how to integrate citizen experience with urban data	5.1	Contextual interviews	Evaluating the usability of the RJ open data website
			5.2	Diary study	Recording the experience of commuting and weather conditions
			5.3	Sentiment analysis	Extracting tweets related to weather and transportation hashtags; Sentiment analysis using an AI model
	6	**To test** the use of mixed data with a participatory design process		Co-design workshop	Collaborative analysis with the collected data

Table 1 – Research Objectives and Methods Description

[2] Data.Rio is the open data portal of Rio de Janeiro for disseminating public data produced by its various departments. It follows the concept of "citizen cities", focusing on transparency, open data, and participatory platforms. For more information, visit the website: https://www.data.rio/

This thesis represents a multidisciplinary research endeavor, exploring themes from urbanism to design (Figure 1). In the initial chapters, we delve into issues related to the city, data, and design. **Chapter 2** defines the concepts of smart cities, discussing sustainability, urban mobility, technology, data, citizen privacy, and mobility as a service. Moving to **Chapter 3**, we present the theoretical framework for human-centered design, tracing the evolution of the design field to its current engagement with complex systems and services, culminating in the co-design process and citizen participation.

In **Chapter 4**, we aim to address the question: What challenges are encountered in projects involving big data and citizen participation? This will be achieved through an analysis of the Civitas projects and relevant interviews.

Building on the identified challenges, we transition to the next phase, seeking to answer how can the solutions found increase citizen participation and make urban data more accessible. We explore the collection and analysis of mixed data exemplifying the question: What is the effect of weather on urban mobility?

Chapter 5 delves into the exploration of collecting mixed data through urban open data, diary study, and sentiment extraction and analysis from social media. In **Chapter 6**, we tested a co-design workshop with data visualization tools. **Chapter 7** is reserved for the conclusion of the thesis.

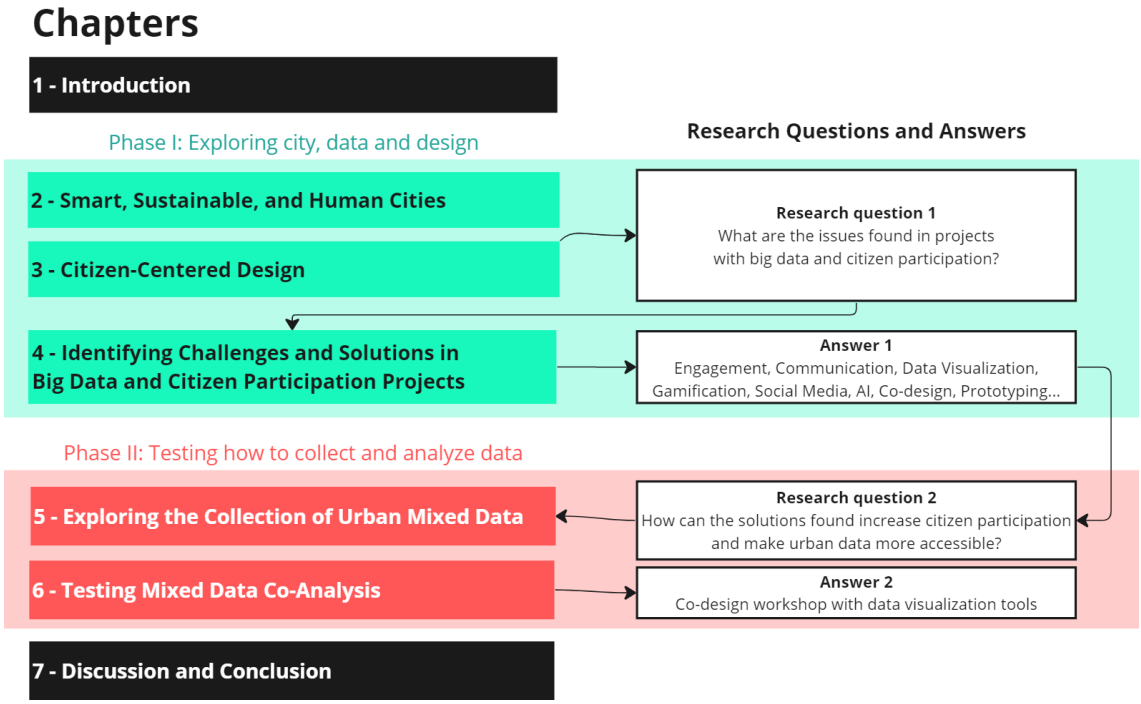

Figure 1 – Overview of thesis structure

Source: Adapted from Pannunzio (2023)

2.
Smart, sustainable, and human cities

The concept of a Smart City lacks a clear and comprehensive definition. The distinction between smart cities and related concepts like digital or creative cities remains unclear, with multiple definitions available and no singular format encompassing all aspects (Letaifa, Ben, 2015). There is considerable ambiguity in defining smart cities, and despite some recurring characteristics, no consensus has been reached (Stevens, Youssef and Salmon, 2019).

In this chapter, we provide different definitions that we found during our literature review. We also present the definition that we will be using in our research. Moreover, we explore the subject of urban mobility and its relation to sustainability and climate change. We discuss the rise of urban technology and data availability, which raises significant privacy concerns. Lastly, we conclude with an analysis of the smart mobility-as-a-service approach.

2.1.
Smart Cities definitions

The concept emerged in the 1990s with new technologies as an alternative to traditional planning modes (Fernandez-Anez, Fernández-Güell and Giffinger, 2018). According to Letaifa, Ben (2015), the term "smart cities" differentiates itself from other concepts (smart, sustainable, creative, livable) by providing a balance between technology, people, and institutions. Alawadhi *et al.* (2012) categorize smart cities into three components:

- **Technology:** hardware and software infrastructure;
- **Human:** creativity, diversity, and education;
- **Institution:** governance and politics.

In addition to the three categories, sustainability incorporates key elements in defining smart cities. Brundtland (1987 apud Desdemoustier, Crutzen and Giffinger, 2019) defines sustainable development as a development that meets the needs of the present without compromising the ability of future generations to meet their own needs. According to Giffinger *et al.* (2007), a smart city does not focus

only on one aspect of city development but on a broad range of six characteristics:

1. Smart Economy;
2. Smart People;
3. Smart Governance;
4. Smart Mobility;
5. Smart Environment;
6. Smart Living.

Castro (2019) believes that Smarter Cities are based on five pillars: technology; for citizens; quality of life; new economy; and resilience. According to the author, a Smart City is a place that works towards improving the lives of its citizens. This perspective prioritizes the citizens' needs, making their lives better without requiring them to understand the intricacies of the city.

For Kitchin (2015), the concept of smart cities has grown among industry, government, media, and academia, referring to the use of information and communication technologies (ICTs) to stimulate economic development and increase programs for urban management. The author emphasizes that for governments smart cities are the path to socioeconomic progress and more livable, safe, functional, competitive, and sustainable cities.

Desdemoustier, Crutzen and Giffinger (2019) distinguish two types of publications that define smart cities. One originates from European universities with a holistic conceptualization, integrating notions related to human and social capital, governance, sustainable development, the environment, etc. The other is based on technological understanding and data orientation, produced by the industrial world, referring to techno-centric smart cities.

Cisco (2022) defines a smart city as using digital technology to connect, protect, and improve citizens' lives. Internet of Things (IoT) sensors, video cameras, social media, and other data sources act as a nervous system, providing constant feedback to the city manager and citizens for decision-making with information. According to IBM, cities should use new technologies to transform the urban system, optimizing the use of limited resources and thus becoming smarter (Dirks and Keeling, 2009).

The McKinsey Institute's report (2018) states that the concept of a Smart City puts data and digital technology to work to improve the quality of life. For this,

three layers work together:

- **Technology Base:** Includes smartphones and sensors connected by high-speed networks. Sensors capture data on traffic, energy consumption, air quality, and other aspects of life.
- **Applications:** Translate raw data into alerts, insights, and necessary actions. Tools are available in different areas: security, mobility, health, energy, water, waste, economic development, engagement, and community.
- **Public Usage:** The success of applications depends on their widespread use and ability to change user behavior. Many apps put the user in control, providing greater transparency in the information available to help them make better choices.

According to Caragliu, Bo, Del and Nijkamp (2011), a city becomes smart when it invests in human and social capital, traditional and modern communication infrastructure, fostering the growth of a sustainable economy with quality of life and the management of natural resources through participatory governance. The Brazilian Network of Smart and Human Cities (Rede Brasileira de Cidades Inteligentes e Humanas, 2017) adopts the concept of smart and human Cities that prioritize well-being, quality of life, and citizen empowerment through collaborative actions, advanced technologies, and a transparent, evolving infrastructure.

OECD (2020) defines smart cities as “initiatives or approaches that effectively leverage digitalization to boost citizen well-being and deliver more efficient, sustainable and inclusive urban services and environments as part of a collaborative, multi-stakeholder process” (p.8). Although digital innovation remains central to the concept, the organization believes a human-centric approach is the key to making a city smarter.

For this study, we considered the concept that combines technological, human, governmental, and sustainable aspects (Desdemoustier, Crutzen and Giffinger, 2019). The proposal is a city with technical resources and a citizen with a better quality of life through participative sustainable governance.

2.2.
Mobility and environment

As previously outlined, Giffinger *et al.* (2007) structure smart cities around six characteristics, including smart mobility and environment, which will be discussed in this section. The authors emphasize that each category incorporates interconnected factors. In the realm of Smart Mobility, accessibility, the presence of information and communication technologies, and the implementation of modern, sustainable transportation systems are highlighted as crucial aspects. Conversely, the Smart Environment category is linked to natural conditions, encompassing climate, green spaces, pollution, resource management, and initiatives for environmental protection.

The connection between mobility and the environment is complex and requires careful consideration in urban planning. The nature of urban mobility significantly contributes to the environmental sustainability of a city. The choices made in transportation systems not only impact how people move within the city but also influence the overall environmental footprint. Additionally, the interplay between transportation options and housing design is a key factor to consider. Furthermore, the effects of the climate crisis have implications for both housing infrastructure and mobility strategies. Transport planning, as outlined by Magagnin and Silva (2008), encompasses concepts related to land use and the environment, emphasizing the need for an integrated approach. It is essential to recognize that these aspects are interconnected and should not be addressed in isolation for effective urban planning.

Brazilian law 12,587/12 defines urban mobility as the condition in which people and goods move within urban spaces (Ministério das Cidades, 2013). The National Urban Mobility Policy is based on principles such as universal accessibility; sustainable development of cities in socio-economic and environmental dimensions; equity in citizens' access to public transportation; efficiency, efficacy, and effectiveness in providing urban transportation services; democratic management and social control of the planning and evaluation of the National Urban Mobility Policy; safety in people's movements; fair distribution of benefits and burdens resulting from the use of different modes and services; equity in the use of public circulation spaces, roads, and thoroughfares; and efficiency,

efficacy, and effectiveness in urban circulation.

Mobility, as defined by Lopes, Martorelli and Vieira (2020), goes beyond transport and traffic issues; it encompasses urban displacement, supporting people and goods' movements for daily activities. According to ITF (2021), transportation is linked to individual and collective well-being, while mobility provides the means to reach a destination. They consider equity as the fair distribution of benefits and costs of transportation, even though those who travel less bear the expenses for the journeys of the more fortunate. This includes costs related to automobiles, such as the construction of highways and other infrastructure, noise, and air pollution, and higher rates of traffic incidents, among other factors.

For Magagnin and Silva (2008), urban growth, increased car usage, insufficient urban infrastructure, and environmental pollution impact people's quality of life. These factors contribute to the need for new ways to minimize and address urban problems. The authors highlighted that urban development without environmental balance leads to observed and future consequences, with greenhouse gas emissions being the primary cause of human-induced climate change.

The conventional approach of solving individual problems in isolation is no longer effective for addressing contemporary challenges due to their interconnected nature (Magagnin and Silva, 2008). Transportation plays a multifaceted role in contributing to numerous United Nations Sustainable Development Goals (SDGs) (Figure 2). This unified approach to mobility demonstrates that it intersects with and is influenced by various areas.

Although there is no single definition of sustainability, sustainable development, or sustainable transportation, a common point is the balance between environmental, social, and economic qualities (Steg and Gifford, 2005). According to Cebreiros and Gulín (2014), environmental issues are a concern, and future cities need to promote effectiveness in their basic systems (water, energy, transportation), ensuring the quality of life for citizens. The efficient management of resources poses significant technological and social challenges, and the smart concept emerges to respond to these challenges.

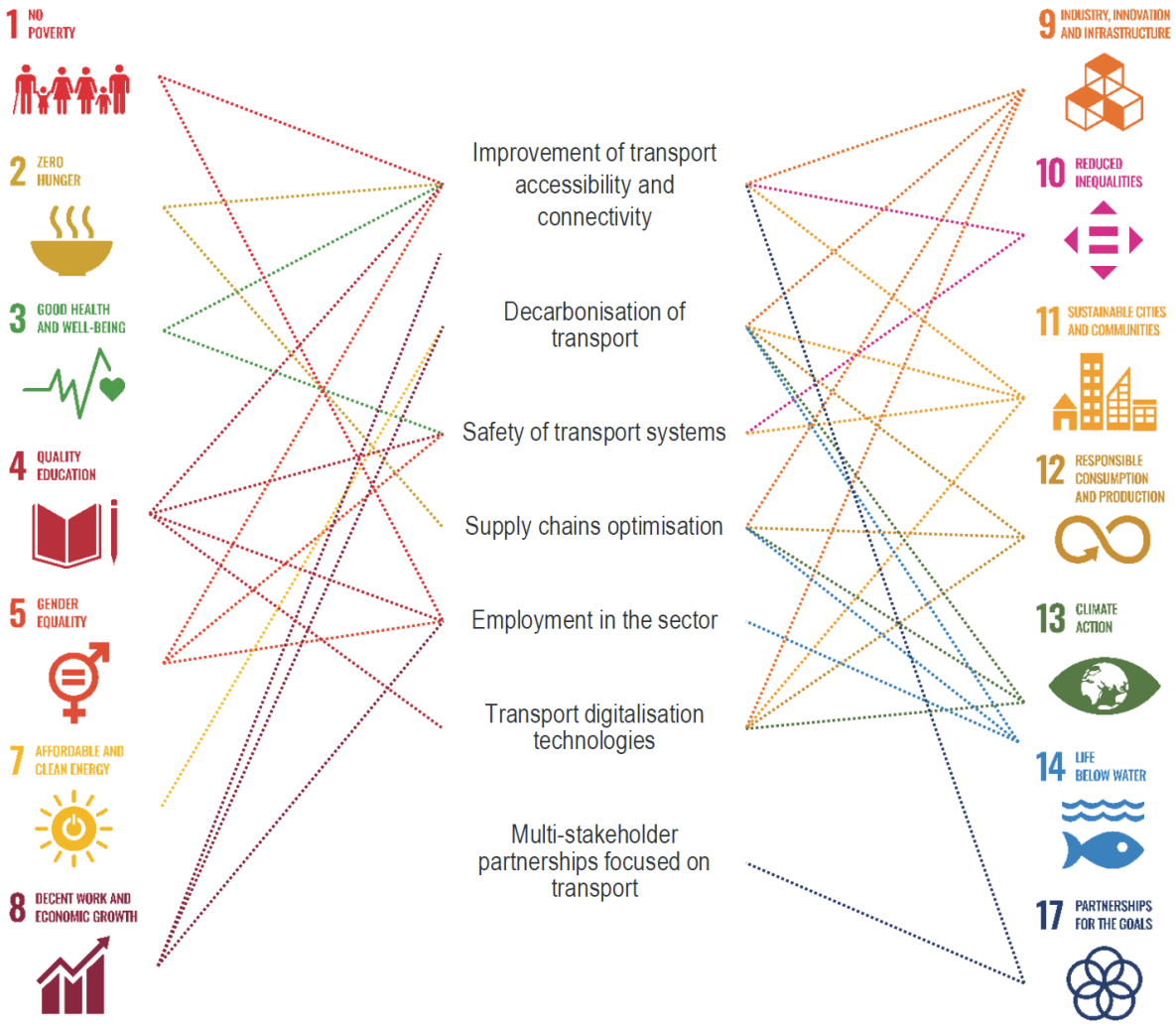

Figure 2 – The relevance of transportation to the Sustainable Development Goals (SDGs)

Source: ITF (2021)

Urban development without environmental balance generates consequences already observed today and will be exacerbated in the future. According to Medeiros (2019), greenhouse gas emissions have been increasing steadily and are the primary cause of human-induced climate change.

Lemos (2010) argues that the era of uncertainties and risks presents a significant challenge to urban planning. Urgent reformulation is required to address the demands of climate change, especially considering the vulnerability of cities to extreme weather events. Cities are vulnerable to climate hazards such as flooding, landslides, heatwaves, and storm surges, which can compromise infrastructure and disrupt essential services, including transportation (Eichhorst, 2009).

Additionally, urban mobility is a contributor to rising temperatures.

According to ITF (2021), vehicle energy use accounts for 25% of direct CO2 emissions. The transportation sector relies heavily on petroleum, representing 92% of total transport consumption, making it a major contributor to climate change, even without considering emissions from fuel production, vehicle manufacturing, and infrastructure construction.

According to the IPCC (2021), human influence has unequivocally warmed the atmosphere, oceans, and continents at an unprecedented rate for at least 2,000 years. Since 1850, each decade has been progressively warmer than the previous four. Human-induced change is already affecting all regions of the planet, with stronger evidence observed in extreme events such as heatwaves, intense precipitation, droughts, and tropical cyclones.

To face these changes and climatic events, cities need resilient and adaptable planning for an uncertain future. According to UNDRR (2017), resilience is the capacity of a system, community, or society exposed to hazards to efficiently resist, absorb, accommodate, adapt, transform, and recover from their effects, encompassing the preservation and restoration of essential structures and functions through risk management.

IPCC (2015) defines resilience as the capacity of social, economic, and environmental systems to deal with a dangerous event or trend, responding or reorganizing to maintain their essential function, identity, and structure while maintaining the ability to adapt, learn, and transform. They defined adaptation as the process of adjusting to actual or expected climate and its effects.

According to Lemos (2010), the adaptation of cities can include measures to address future impacts, anticipating the solution to problems and disasters, as well as existing risks and impacts. The author highlights the importance of these initiatives, as the risks related to existing climatic phenomena already justify the adoption of adaptation measures as a priority, even without considering projections of increased intensity and frequency of these events due to climate change.

The World Health Organization recognizes global warming as a major global health threat, with vulnerable regions facing high susceptibility (Miranda *et al.*, 2023). Heat affects human health directly and indirectly (Cheshire, 2016), with prolonged heat stress periods increasing significantly in major populated cities. Climate change uncertainties exacerbate a socio-environmental crisis, emphasizing the vulnerability of socio-economic and physical-spatial systems (Lemos, 2010).

The influence of transportation systems on climate change is well-established, as are the impacts of climate change on this sector. Mehrotra *et al.* (2012) summarize this relationship:

- **Transportation Impact on Climate Change:** Different motorized transportation modes have distinct carbon footprints. In cities with concentrated urban centers, mass transportation is the most efficient system, with railways surpassing bus systems, minimizing greenhouse gas emissions per passenger. Between 1950 and 1997, the global automobile fleet grew five times faster than the population.
- **Impacts of Climate Change on Transportation:** The escalation of hot days, heatwaves, arctic temperatures, rising sea levels, intense precipitation events, and hurricanes are prominent aspects of climate change, exerting substantial adverse effects on transportation. The array of impacts is far-reaching, encompassing structural and material damage, as well as the disruption of transportation services for users, contingent on factors such as facility type, proximity to waterways, and the materials and design employed.

According to Medeiros (2019), service providers and authorities need to change how they manage their multimodal transportation infrastructure, integrating them. A city's ability to adapt to climate-related impacts will determine the resilience of the transportation system. For the author, urban planning is connected to climate issues, influencing factors such as the compactness of cities, the capacity of traffic circulation routes, and the consideration of drainage and risk areas in the layout. These are examples of how climate is indispensable in shaping cities.

Adapting urban transportation to climate change requires cooperation among various actors, including public authorities responsible for resilient infrastructure, transportation service providers offering suitable vehicles, and road users making choices influenced by accessible, efficient, comfortable, and safe mobility options (Eichhorst, 2009). Awareness and information about the need for adaptation are crucial components to enhance decision-makers and societal acceptance.

With the advancement of Information and Communication Technologies (ICTs), there are new communication possibilities for urban transportation development. The IPCC (2014) highlights opportunities for disseminating relevant

information, such as weather forecasts, warnings, market information, and bottom-up processes like crowdsourcing for local flood levels, disease outbreaks, and disaster response management.

In summary, the intricate relationship between climate change and urban mobility emphasizes the need for adaptive measures. These measures extend beyond technical modifications and call for behavioral shifts from transportation users, demanding a transformation in planning approaches recognized as a social learning process. IPCC (2014) identifies three ways technology can help in adaptation and development: monitoring climate change, raising awareness, and enabling network-based governance in open organizations. The design could play a crucial role in implementing these effects by assisting in monitoring changes through accessible dashboards, supporting communication for awareness, and facilitating network-based governance.

2.3. Technology and urban data

Technological advancement has enabled the generation of a large volume of urban data, yet these pieces of information are often underutilized, presenting untapped potential for solutions in urban mobility (Kitchin, 2014). The data captured by sensors empower governments to make more informed decisions (Kitchin, Lauriault and McArdle, 2015). However, the challenge lies in the management of these data, posing a problem for smart cities, along with their application in public policies (E. Innes and Booher, 2000). Therefore, there is a need to understand how we can better leverage this data, contextualizing it with citizen participation.

According to Barkham, Bokhari and Saiz (2018), several trends have facilitated the transfer and sharing of data, including the growth of computing, interconnected networks, and digital devices. Alongside the generation of interconnected structured data, the rise of computerized algorithms and the expansion of affordable storage capacity have become instrumental. As a result, a platform can store various data sources and index them together, collecting in real-time or at irregular intervals, depending on the frequency of collection.

Big data is the massive, dynamic, varied, detailed, interrelated, and low-cost data sets. This data can be connected and used in various ways, such as static

snapshots or dynamic correlations, aggregation, hypotheses, models, complex and sophisticated simulations, and theories (Kitchin, 2013).

Nguyen (2018) defines five core elements of big data, the five Vs: volume, velocity, variety, veracity, and value. Volume is the amount of data created in a unit of time; velocity refers to how fast new data are generated and transmitted; variety indicates different data formats generated in significant volume; veracity refers to the fact that the quality and accuracy may not be at high levels; value refers to the individual or organizational capability of turning big data into values, which includes an ability to collect and then leverage the data to achieve specific goals.

In the context of connected cities, there are various ways to capture data. Barkham, Bokhari and Saiz (2018) categorize these sources into five types: sensors, apps, crowdsourcing, geographic information system, and administrative sources:

- Sensors are perhaps the most well-known form of big data collection. They can be placed in buildings to measure various inputs such as light, temperature, air quality, movement, or the speed of people.
- Smartphone apps also generate significant data, such as traffic data, providing real-time information to drivers. Smartphones also enable users to consciously submit data, either through apps that monitor their behavior or through other means.
- Crowdsourcing involves many people collectively producing data on specific issues. One form of crowdsourcing is known as citizen science, where volunteers generate, prepare, and process detailed observations and measurements of a particular phenomenon.
- Geographic Information System enables data generation by social media users; chip readers, like transit cards, can be used in studies on human behavior.
- A common trend in many cities is the digitization and compilation of administrative data spread across various city departments. To enhance transparency and accountability, several cities are moving toward a culture of open data.

Despite the abundance of data, many cities fail to fully leverage its potential. Open data availability facilitates greater use and innovation, allowing more individuals to utilize and develop solutions. Data for repositories can originate from

passive sources, captured automatically, or active sources, with citizens consciously contributing to it. The research approach chosen also determines the nature of the collected data, whether quantitative or qualitative.

The principles of open government, such as transparency, participation, and collaboration, are central keys to integrating citizens within the smart city paradigm (Consoli *et al.*, 2017). The dissemination of public information does not only result in a data openness policy but can also foster more social innovation. The open data movement introduces a new aspect of city building, becoming a means to co-create meaningful applications that enrich people's lives (Mulder, 2015a).

Turning data open and accessible is useful for the design process. The Decode project, funded by the European Union, highlights the need to move towards a data commons model, where data can be shared transparently and securely for public value while maintaining personal and collective control (Bass and Old, 2020). Meanwhile, in another European-funded project, Open4Citizens, the results emphasize data's democratizing power and design's role in supporting open data as a resource (Morelli *et al.*, 2018). Furthermore, open data can complement traditional qualitative research methods, providing scale and access to a digital footprint of human activity (Kun, Mulder and Kortuem, 2018). By embracing open and accessible data, designers can unlock the potential of data to enhance the user experience, improve service efficiency, and drive innovation.

In the context of big data in smart cities, there is a challenge in managing data and applying it to public policies. Sensors enable the capture of data never before available, allowing for more well-founded and informed decision-making (Rowland and Charlier, 2015). Therefore, for Kitchin, Lauriault and McArdle (2015), indicators are crucial for quantifying and tracking information about changes in a specific phenomenon, providing a measure to analyze various aspects of a city and monitor its performance. These trends can be tracked and revealed through graphs and inserted into models that attempt to explain patterns or simulate and predict what could happen under different circumstances.

According to Kitchin, Lauriault and McArdle (2015), cities' open data can be tracked, monitored, visualized, and analyzed using tools like indicators and dashboards. Dashboard visualization, with comprehensive data collection, has the potential to enhance urban management by summarizing and communicating statistical graphs, diagrams, or maps. Dashboards, as defined by the authors, serve

as central tools for analyzing and interpreting reference values, revealing possible patterns and trends. They can display various indicators in a single graphical interface, making visualizations exportable for diverse uses. Some cities adopt a contextual approach, integrating data with other information, and recognizing the multiple interrelated systems within a complex city, which cannot be managed by a simple indicator.

With the widespread use of cameras, traffic light sensors, smartphones, and location-based apps, traffic engineers can monitor and manage urban mobility at an unimaginable level of detail decades ago. Public managers create mobility models trying to optimize certain aspects of urban life, such as average travel time or the number of road accidents. However, citizen participation in creating these models is insufficient. Consequently, some public policies are not as effective as they should be because they do not consider the needs and expectations of citizens (Cordeiro, Cordeiro and Quaresma, 2021).

Therefore, ensuring citizens' privacy and transparency could foster social engagement and enhance the effectiveness of public policies. In the context of smart cities, interconnected services often expose people's data to government agencies without proper consent, raising concerns about the reliability of government-captured data. This leads to questions about whether the data is used to enhance public services or potentially for population control. Many individuals unknowingly share their data, posing a risk of governments exploiting it for increased surveillance, especially during crises when some protocols may be overlooked.

According to Cavoukian (2009), with technology increasing, it is important to embed privacy directly into the default design process. The author emphasizes the need for a positive-sum paradigm that combines privacy and innovation. Therefore, the future of smart cities should prioritize citizen-centered design, raising awareness of responsible technology use, ensuring anonymity and privacy in data usage, and establishing best practices grounded in ethical principles for assisting the population with improved services (Cordeiro, 2019).

Privacy is paramount in transportation, especially considering the value of location data for comprehending the urban mobility ecosystem. Nevertheless, this data can be highly revealing, providing detailed insights into a user's behavior over time and potentially leading to profiling and individual identification (Cottrill,

2020). As the number of interconnected databases grows, these concerns become even more sensitive, particularly in the context of Mobility as a Service (MaaS).

MaaS refers to integrating various transport services into a unified mobility service (MaaS Alliance, 2022). For users, MaaS enhances value by providing access to various modes of transportation through a single planning and payment channel, breaking down information silos between different transport systems.

Cottrill (2020) emphasizes that MaaS relies on sharing travel-related information, including vehicle availability, origin and destination details, financial information, and social networks, among others. These data may be considered personal and sensitive, subject to various regulations. To ensure the system's efficient operation and alignment with the desired goals, robust data sources from various providers and for different purposes are essential. However, due to the diverse actors involved in collecting and using relevant data, addressing concerns such as privacy and security can be inconsistent or fragmented.

Therefore, increased data availability empowers the modeling of user experience, enabling MaaS to modify citizen behavior by offering tailored mobility solutions, potentially achieving more sustainable transportation. Implementing and providing innovative services, could shift the transportation paradigm from ownership-based to access-based, improving accessibility and equity (Musolino, Rindone and Vitetta, 2022).

Despite acknowledging the potential impact of increased data availability on shaping user behavior and fostering sustainable transportation through tailored MaaS solutions, the complexities of urban environments present multifaceted challenges. With the growing complexity of cities, Stevens, Youssef and Salmon (2019) argue that any tactic that only addresses parts can not achieve sustainable long-term improvement. The authors propose that human factors and ergonomics methods offer a new approach to capturing the human requirements of urban form, with a suite of accessible methods and the means to explore the inherent complexity of cities. In their view, in a world with desired smart cities, we need to explore the potential for new processes of urban development. In this way, the next chapter will present this culture change in the design field.

3.
Citizen-centered design

Design is a dynamic field that operates on various fronts, and over time this scope has expanded. The artifact, once material, has evolved into something digital and even systemic. Despite the frequent updates in the discipline, what has remained constant is the focus on people. When the system in question is a city, the design perspective is directed towards the citizen.

According to Mulder (2015b), this perspective of human-centered design must be changed to citizen-centric design when the system is a city. She believes that unpredictable futures need a citizen-centric design. For the author, architecture must embrace meaningful design with a new city-making paradigm, combining top-down public management with bottom-up social innovation. Social challenges could not be reached without citizens' intention and commitment. Therefore, the citizens are in the cities' hearts, so they should be at the heart of the changes. Mulder (2015b) argues that students learn to take a human-centered design perspective in small-scale experiments. However, they should understand people in their context, embracing the human scale, to design a livable and sustainable urban environment.

This thesis seeks to explore and understand the citizens' experience through the perspective of design, recognizing it as a crucial tool for comprehending their needs and developing solutions for intricate problems. The chapter is structured into five sections: firstly, it delves into the evolving role of design, tracing its trajectory from material artifacts to digital and systemic realms. Subsequently, it explores the service perspective, particularly in the context of public services within smart cities. The discussion then shifts towards the role of design in fostering social innovation and encouraging citizen participation, emphasizing its function as a facilitator in involving users in the resolution of complex issues. Finally, the chapter examines the role of design as a storyteller, underlining its capacity to illustrate and convey meaningful narratives.

3.1.
The human-centered design approach

The design discipline has changed, progressing through various paradigms over the years. Giacomin (2014) traces the evolution from ergonomics to “human factors, usability, user centred design, inclusivity, interaction design, empathic design, design for product experience, design for customer experience, design for emotion, emotionally durable design, sensory branding, neurobranding, service design” (p.611-612) and the author finished with the umbrella paradigm of human centred design.

According to IEA (n.d.), the terms ergonomics and human factors are often used interchangeably (HFE) and refer to the scientific discipline concerned with understanding interactions among humans and other elements of a system. This discipline applies theory, principles, data, and methods to optimize human well-being and overall system performance.

According to Dittmar *et al.* (2021), the changing technological landscape is reshaping the interpretations of well-being, cognitive and system performance, and thereby influencing the goals of HFE. For the authors, the approach now allows for a broader examination of artifact interaction, expanding from usability to individualized user experience, with digital products permeating the personal sphere.

The human-computer interaction research is no longer just on efficiency in the workplace, as elucidated by Lazar, Feng and Hochheiser (2017), but encompasses considerations of user preferences, willingness to use interfaces, and the specific environments in which technology is employed. Nowadays, contemporary research considers topics such as mobile devices, gestures, sensors, embedded computing, sustainability, big data, collaboration, accessibility, and others (Liu *et al.*, 2014).

The understanding of systems has been expanded, with a broader spectrum of application domains, including public services, as elucidated by Stevens *et al.* (2018). A system with many elements, such as cities and urban systems, would be complex. Furthermore, the authors highlight parallels between Human Factors and Urban Design disciplines. Both operate within complex systems settings and share methods for data collection. In this regard, it is essential to comprehend how to

effectively utilize this data by contextualizing it. The human-centered design approach is aligned with this objective and holds the potential to address this challenge.

Giacomin (2014) defines human-centered design as a multidisciplinary activity to clarify the purpose and meaning of the product, system, or service, considering the design to be a pragmatic and empirical approach to making sense of the world around us. This interpretation is based on scientific facts about human physical, perceptual, cognitive, and emotional characteristics, followed by progressively more complex, interactive, and sociological considerations. Unlike other practices, the author emphasizes the centrality of questions, insights, and activities from the end-users, as opposed to being solely driven by the designer's creative process, materials, or technological resources.

According to Sanders and Stappers (2008), the landscape of human-centered design research encompasses the user-centred design approach ('user as subject') and the participatory approach ('user as partner'). In the participatory design approach, the authors delineate the terms co-design and co-creation: co-creation refers to any act of collective creativity, and co-design would be co-creation applied to a design process. In their view, the participant becomes an expert in their experience, and the researcher becomes a facilitator who will enable user participation in the design process. Our study follows this approach, progressing from observation and individual involvement to engaging in citizen participation, further enhanced through big data integration.

The researcher used to act as an expert, primarily observing and interviewing passive users who contributed by performing tasks and giving opinions. In the realm of cognitive ergonomics, a specialization of HFE, Dittmar *et al.* (2021) say that the unit of analysis has expanded from predefined cognitive tasks to encompass practical collaborative activities. This shift involves a more active role, incorporating users and stakeholders from the earliest design stages. For the authors, this approach is influenced by organizational ergonomics, which considers the interplay between individuals, collectives, and organizations.

In the context of smart cities, characterized by a prevalent technological framework, HFE research works on the relationship between these new elements. This juncture marks a critical intersection for human factors and urban design, influencing the design of the future world, which will be increasingly technology-

centric (Stevens *et al.*, 2018). HFE could play a key role in ensuring that future systems are more human, sustainable, and liveable. According to Oliveira and Campolargo (2015), cities can only be smart if they exploit data analytics to provide a human-smart city. This involves not only automating routine functions but also improving the quality of life of its citizens, building a trusted governance model, and engaging and empowering citizens in co-creating solutions for collective social challenges.

The use of data is an essential component of human-centered design. As technology is an integral part of life, it is impossible to separate artifacts from their role in human activity (Dittmar *et al.*, 2021). Giaccardi and Redström (2020) advocate for a shift from human-centered design to more-than-human design, emphasizing a transition beyond the traditional one-to-one relationship between individuals and technology. The expanded perspective involves managing, presenting, and negotiating various relations in parallel, without privileging a specific relationship above others. The transition highlights the need to address the complex network of relationships within a technological context.

Mauri and Antonovsky (2021) believe that some tendencies can hinder the analysis of human factors in complex socio-technical systems. These include a tendency to uncritically accept unsubstantiated assumptions and an inclination in experimental psychology to test isolated constructs in simulated environments. The authors advocate for mixed methods to address these challenges.

Combining big data approaches with a small user sample offers advantages for both data collection methods, enhancing comprehension of correlations and causality. Big data can identify potential solutions, while qualitative methods can explore the underlying reasons. Conversely, qualitative research may identify future trends or human behavioral patterns validated by big data (Lehikoinen and Koistinen, 2014).

However, data analytics grapple with the complexities of human systems, marked by contradictory relations and the intricacies of social, political, economic, and historical contexts, leading to potential false correlations (Kitchin and Lauriault, 2015). A collaborative HFE approach, central to the hypothesis of this thesis, can navigate these challenges. It highlights how emerging technologies generate and collect big data, which can be correlated with small data from citizen participation.

3.2.
Service design and mixed research

In recent years, the term "product" has expanded from material objects to a set of services. According to Meroni and Sangiorgi (2011), what is produced in the new economy is not consumer goods but systems directed toward a specific purpose. Thus, the role of design has also expanded with the advent of new technologies, especially in the fields of information and interaction systems, increasingly moving into the realms of intangibles (Matias, 2014).

Meroni and Sangiorgi (2011) argue that services are hybrid artifacts that cannot be reduced to mechanical entities, as they are composed of places, systems of communication and interaction, human beings, and their organizations. For them, services are permeated with human activity, making them un-designable. However, this complexity and unpredictability necessitate a new, service-oriented design culture to solve complex problems. This change in design culture reflects a change toward an economy based on services, networks, and sustainability.

With the evolving role of designers, service design (SD) has emerged as a response to the changing landscape. According to Meroni and Sangiorgi (2011), in the 20th century, designers focused on producing simple objects through defined processes. However, in the 21st century, the design process considers unpredictable factors, acknowledging the complexity of the new economy. The traditional design "object" shifts into a dynamic "process" that unfolds over time. In this context, design no longer merely creates a tangible product but rather facilitates and shapes innovative outcomes. Consequently, the result becomes unpredictable, extending beyond the control of the design team.

Stickdorn *et al.* (2018) examine the history of SD and provocatively suggest that this approach only involved working with services using design methodology. They propose that service designers were just one of many professionals involved in creating services, alongside disciplines like systems engineering, marketing, operations management, customer service, and "the organization". However, Matias (2014) argues that what sets SD apart is its focus on designing the consumer experience based on the principles of emotional design. Despite various professionals engaging in service-related work, an increasing minority specifically refers to this practice as service design.

According to Meroni and Sangiorgi (2011), SD refers to how human beings relate to other human beings through the mediating influence of products, which could be physical artifacts, experiences, activities, or services. This method adopts the mindset and process flow of design, combining an active and iterative approach with a flexible set of tools borrowed from marketing, branding, and user experience, among others (Stickdorn *et al.*, 2018).

SD would help organizations see their services from the customer's perspective. It is a design approach that balances customer needs with those of the business, aiming to create continuous and high-quality experiences. Stickdorn *et al.* (2018) summarize service design as a human-centered, collaborative, interdisciplinary, and iterative approach that uses research, prototyping, and a set of easily understandable activities and visualization tools to create and orchestrate experiences that meet the needs of the business, the user, and other stakeholders. According to the authors, the principles of service design are:

- **Human-centered:** Considers the experience of people affected by the service.
- **Collaborative:** Stakeholders must be actively involved in the process.
- **Iterative:** An exploratory, adaptive, and experimental approach.
- **Sequential:** The service should be visualized and orchestrated as a sequence of interrelated actions.
- **Real:** Researching needs, prototyping ideas, and highlighting intangible values as physical or digital reality.
- **Holistic:** Services should sustainably meet the needs of all stakeholders throughout the service and across the entire business.

The core of any design process is the divergent and convergent approach, creating and reducing options (Figure 3). According to Stickdorn *et al.* (2018), first comes the research phase, where knowledge is generated through methods to focus, organize, and extract meaningful information. Then the ideation phase, with the creation of opportunities that are filtered through decision-making processes to arrive at several ideas. Moreover, lastly, the prototyping and implementation phases, exploring and building solutions, and then focusing again. For the authors, the distinction between service design and other design disciplines lies in the specific set of tools and methods employed, rather than in the design process itself.

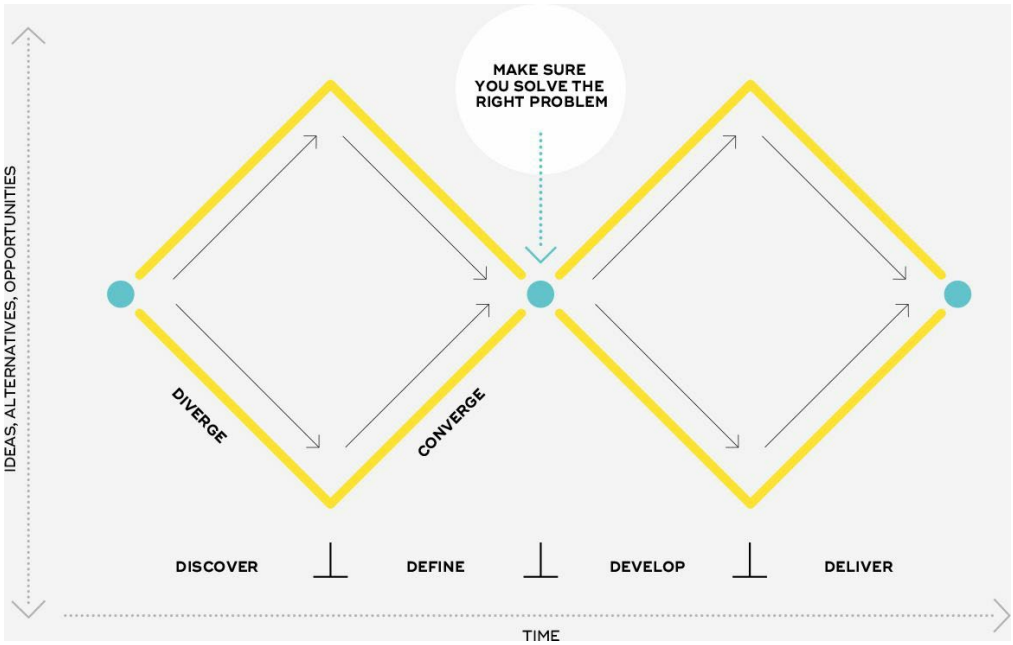

Figure 3 – Double diamond diagram illustrating divergence and convergence

Source: Stickdorn *et al.* (2018)

A crucial phase is the research step, which generates knowledge about the problem. In this human-centered approach, the information collected gives a complete and more contextualized picture of the service. Research with users is essential in SD, and it is not easy to propose a service without listening to users and discussing and testing the proposal with them (Meroni and Sangiorgi, 2011).

Research data is one of the key inputs for service design. It consists of facts that can be collected, synthesized, interpreted, and analyzed to address questions and communicate discoveries or even help predict outcomes. Research activities gather numerous facts, observations, and a variety of materials (Figure 4). Stickdorn *et al.* (2018) categorize these empirical data into raw and interpreted data:

- **Raw data:** These are data collected during research that have not been filtered by a researcher, describing a situation without reflecting interpretations.
- **Interpreted data:** These represent the researcher's attempts to explain or understand raw data by summarizing patterns or concepts found. Interpreted data reflect the researcher's reasoning and may be affected by potential cognitive biases. To minimize biases, interpreted data should be supported by raw data.

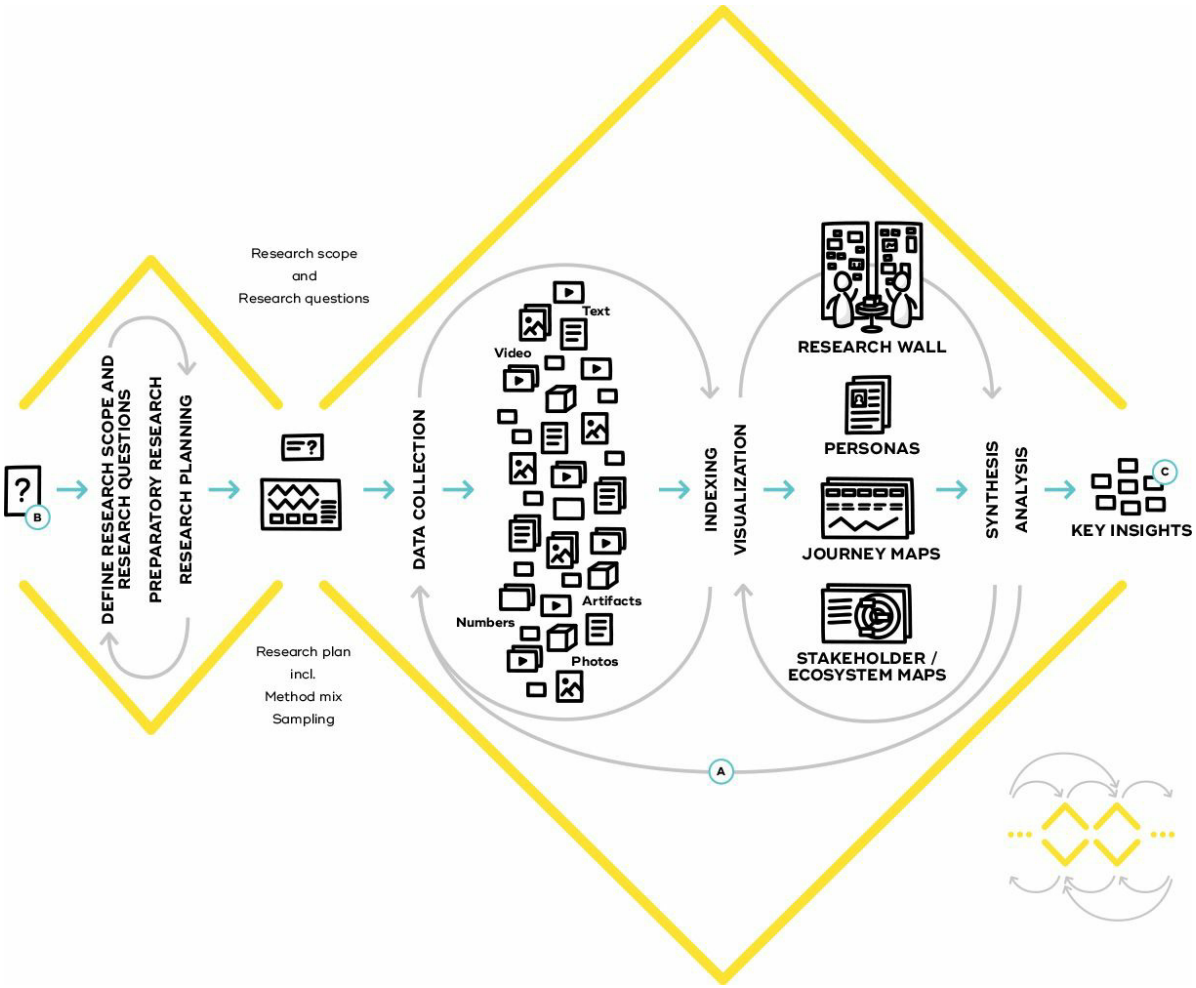

Figure 4 – Research activities in an iterative sequence

Source: Stickdorn *et al.* (2018)

One way to minimize researcher bias is by combining different data forms with mixed methods. SD, with its multifaceted layers of interaction, benefits from exploring different aspects of the service experience using a diverse range of user data sources. In addressing complex issues within the service design process, research becomes pivotal. Combining both quantitative and qualitative data offers a more comprehensive and less biased perspective. This approach is advantageous because every method comes with weaknesses, and by triangulating data sources, the shortcomings of each are mitigated (Creswell and Creswell, 2018).

Service design is connected to social innovation opportunities, as suggested by designer Ezio Manzini, who advocates for a sustainable and social economy. He believes that this economy is not based on consumer goods but on complex products based on the interaction between people, products, and places, relying on increased

social and technological networks (Matias, 2014).

Environmental concerns, as highlighted by Meroni and Sangiorgi (2011), are integral to the development of new services that systematize and value social resources. However, Matias (2014) critiques the touted benefits, questioning the impact on the social economy, underlying interests, and potential consequences. He argues that many services, conceived for profit, contribute to social fabric wear, environmental resource depletion, and poverty, and do not enhance the quality of life. In Matias's view, while SD attempts to transform social relationships, it may still prioritize profit over people.

The service design process can be applied for different purposes. In this thesis, we are analyzing mobility in the context of smart cities. For this, we believe that a collaborative design approach could involve citizens in the stages of research, ideation, and implementation. The next section will detail this new role of participatory design for social innovation.

3.3. Design in social innovation and citizen participation

The design process offers numerous paths, with the participatory approach being a constant in citizen-centered design. Co-design enables citizens to collaborate in shaping urban services, ensuring that the diverse needs and perspectives of the community drive social innovation with a civic focus.

The limited involvement of citizens hinders thorough analysis, often leading to an excessive focus on technological aspects rather than addressing citizens' needs. Oliveira and Campolargo (2015) introduce the term "Human Smart City," emphasizing that new technologies should not serve as an end in themselves. Instead, they propose their implementation with active involvement from the population in co-creating solutions for collective social change. This concept promotes the creation of an intelligent environment that fosters intelligent living through smart governance. For the authors, citizen participation in idea generation is indispensable for establishing a trustworthy and collaborative urban environment.

The participatory design movement, as outlined by Dittmar *et al.* (2021), has its roots in Scandinavia. Researchers in this region emphasized the significance of people, incorporating considerations of ergonomics and safety in interactive systems. This movement evolved as unions and university researchers collaborated

to develop a participatory design approach that actively encourages robust user involvement throughout the design process.

Steen, Manschot and Koning (2011) categorize the design process into three approaches to interacting with users: "say," "do," and "make." Interviews allow listening to what others "say" and interpreting their expressions. Observation enables the observation of what others "do" and how they use products or services. "Make" is associated with co-design, where people can explore and articulate their needs by "making" solutions together. According to the authors, the main benefit of these approaches is organizing group creativity.

Manzini (2015) characterizes co-design as a multifaceted dialogue among individuals and groups shaping design initiatives. It represents a social exchange where diverse actors interact, ranging from collaboration to conflict, and occurs in different contexts, whether in real-time or offline. According to him, every co-design process involves the collective generation of ideas emerging from conversations among social actors. He advocates for collaborative creation in the design process, emphasizing that participation is not limited to expert designers.

As mentioned earlier in this chapter, the role of the designer is as an actor capable of listening to users and facilitating discussions. According to Meroni and Sangiorgi (2011), designers can be facilitators and provocateurs: the tools they use serve to visually co-create ideas within the group and also stimulate discussion with original views and proposals. The evolution of the designer's role involves acting as a facilitator for solution creation with user participation. The shift from user-centered research to co-design implies a change of function, requiring the generation of new domains of collective creativity and, thus, the development of more sustainable forms of life in the future (Sanders and Stappers, 2008).

According to Manzini (2015), this new designer's role is more about facilitating collaboration among diverse actors than working alone with citizens' data. For the author, social change occurs when citizens actively participate in the co-design process. Design for social innovation involves the contribution of design experts to a co-design process for social change. These roles of designers can be applied in various contexts. When designers function as facilitators, they become crucial in connecting various elements, whether in a social or commercial context. The growth of data emphasizes the fundamental role of design in integrating and translating information.

In this way, the concept of citizen participation is fundamental in the context of the smart city, as Mulder (2018) suggests a need to shift the notion of urban management toward a participative city. This process envisions habitable and sustainable urban environments, extending beyond service-product design, with political, organizational, and even cultural implications. The designer engages with citizens, empowers them, and allows the community to become increasingly reflective and receptive.

Co-creative partnerships could integrate multiple initiatives, enabling them to act as connectors that strengthen social fabric. Mulder (2018) believes that when a group forms from a bottom-up initiative, it gains support and remains representative of the community. For the author, co-creative partnerships benefit from integration and social learning, fostering a more powerful interaction both from the bottom up and from the top down.

Mulder (2018) highlights that one advantage of engaging in co-design and co-creation processes is the potential to streamline and enhance the transparency of municipal administration. However, a significant challenge lies in fostering the active participation of the public in civic life. Establishing trust between city administrations and the community encourages citizen collaboration. Mulder emphasizes the importance of identifying and understanding the diverse needs within the community. Rather than receiving feedback from a limited number of citizens, she underscores the necessity of engaging with and listening to all groups.

Therefore, a central issue lies in the failure to effectively communicate with the population. Frascara (2000) warns that generic messages attempting to reach everyone often end up reaching only a few, thus failing to fulfill their intended purpose. Consequently, when the government does not address the diverse motivations of the public, it essentially speaks to no one. In this context, active participation in public processes becomes crucial for understanding and addressing the varied needs of all social groups.

According to Gidlund (2012), practitioners in public processes for social innovation often struggle with whom to listen to, how to include citizen input, and the limits of their formal positions. Also, certain social groups can be excluded from participation, as public authorities may not see their input as profitable. Meanwhile, Manzini and Cipolla (2019) argue that mainstream city projects prioritize marketability over the complex social fabric of communities, whereas socially

driven projects prioritise collaboration that empowers individuals and communities.

Finally, Cipolla, Serpa and Afonso (2017) emphasise the importance of empowering all groups in social innovation processes to meet everyone's needs, particularly those who have been excluded and discriminated against in the past. A co-design process could open a dialogue with different stakeholders, and through this participatory approach, citizens get involved and empowered, changing the relationship with the city.

Hence, this research aims to illuminate relevant issues by leveraging urban data and citizen participation. We contend that this integration holds the potential to yield solutions, striving for transformative changes toward a more sustainable society in the long run. Climate change, being a complex challenge, stands to benefit from the application of a participatory design approach.

3.4. Design for complex problems

The field of design has grown as the world has become more complex, and issues related to intangible products have expanded the practice of the discipline. In a globalized economy, design could assume a new role in conflict resolution and mediation among stakeholders. Faced with complex problems, designers may become creative problem solvers. According to Bomfim (1997), designers have an innate ability to create new solutions based on acquired knowledge and perceptions.

Cardoso (2011) contends that the complexity of a system correlates with the difficulty of interrelating its components. Complexity implies a system with numerous elements, layers, and structures, where interconnections continuously influence and redefine the system's overall functioning.

Addressing the climate crisis presents an enormous challenge, despite global commitments and positive intentions. Emissions, environmental pollution, and inequality persistently escalate. The Design Council (2021), in its Beyond Net Zero report, emphasizes that this challenge is not solely technical but also creative and social. According to them, design assumes a pivotal role by bridging the gap between technological research and innovation and their practical implementation in social practices.

Design processes have the potential to broaden our understanding of urban life experiences. According to Stevens *et al.* (2018), interdisciplinary

methodologies provide an alternative to the prevailing predict-and-provide mindset in urban and regional development. These methodologies offer more than just normative principles or descriptive visions of technology-rich futures. For them, the traditional business-as-usual approach is no longer sufficient.

Observational studies exploring how people interact with and utilize public spaces, and the resultant impact on their quality, are not novel concepts. However, these studies are now experiencing a breakthrough in practical application, incorporating aspects from phenomenology to behavioral studies (Mews, 2022). Phenomenological research integrates visual and kinaesthetic human experiences in spatial settings, providing an additional perspective on places that can serve as a backdrop for meaningful and rich urban life experiences. As cities grow increasingly complex, Sociotechnical Urbanism urges stakeholders to conceive and design processes that leverage the recognized properties of city complexity (Stevens *et al.*, 2018).

Wicked problems are defined by Kotaniemi, Suoheimo and Miettinen (2023) as unsolvable issues like global warming, unemployment, and social and healthcare services. The world faces numerous wicked problems threatening the delicate balance of the planet and the continuity of humankind. These problems stem from the abuse of nature and social inequality, impacting both survival and coexistence (Manzini, Fuster and Paez, 2023). Addressing wicked problems requires a new mindset, different from traditional design approaches. While designers excel at handling chaos and zooming in and out of problems, dealing with wicked problems requires an additional layer of complexity (Suoheimo, 2020).

Manzini, Fuster and Paez (2023) posit that design plays a pivotal role in enhancing the urban fabric's quality, both in material and relational aspects. By fostering favorable conditions for interactions among individuals, spaces, and the environment, design can conceive and bring into existence novel physical and relational entities. This, in turn, contributes to the development of a denser and more diversified urban ecosystem.

In the complex context of cities, design can act as a mediator, using playful tools to encourage citizen participation. Mews (2022) underscores the potential of play as a framework for comprehending spatial practices and dynamics in public spaces. His thesis posits that a framework centered around play can unveil specific qualities and dynamics arising from play activities in public spaces.

By focusing on everyday life within leisure, empirical research on play in public spaces is poised to enhance our understanding of daily urban life in core urban areas (Mews, 2022). The following section will elaborate on how designers can craft narratives in a more accessible, enjoyable, and empathetic manner.

3.5. Designer as a storyteller

The design process, especially when approached from a citizen-centric perspective, can be a powerful tool for handing over complex ideas and issues. Data visualization could transform raw data into meaningful insights, allowing patterns, trends, and relationships to emerge. Furthermore, storytelling can translate data into narratives that engage and resonate with people. This section explores how the design process plays a role in storytelling, emphasizes the significance of a citizen-centric design process, and demonstrates the effective combination of data visualization and storytelling to communicate complex concepts.

The significant rise of big data across various sectors poses challenges, particularly in data interpretation, and understanding complex data is a crucial skill in an increasingly data-driven world (Souto *et al.*, 2024). D'Ignazio and Bhargava (2016 apud 2018) define data literacy as "the ability to read, work with, analyze and argue with data as part of a broader process of inquiry into the world" (p. 2). Data visualization has become a standard approach to comprehend the surrounding world, extending beyond technical and scientific domains to arts, communications, and services (D'Ignazio and Bhargava, 2018).

Despite the hype around big data and the promised knowledge revolution, D'Ignazio and Bhargava (2018) argue that there is profound inequality in who benefits from data storage, collection, and analysis. For the authors, data has become a currency of power, emphasizing the importance of addressing and mitigating disparities in data literacy. They believe when those in power adopt a discourse with data, those not fluent are actively excluded from collaborative endeavors. This results in data inequality between those proficient in "speaking data" and those who are not.

It's important to note that data visualization is not another technology to integrate into education; it's a form of visual argumentation, more aligned with rhetoric and writing than software coding (D'Ignazio and Bhargava, 2018).

According to Spinillo (2023), data visualization uses visual and interactive displays to enhance understanding, focusing on empathy, managing complexity, and the role of technology. Empathy concerns the user's connection with the information while dealing with complex data involves correlating different types and numerical scales. The challenge is to communicate complexity effectively, making intricate data accessible. However, unnecessary technology in data visualization can lead to cognitive overload and hinder engagement, especially on mobile devices with screen size and interaction limitations.

Data visualization could transform complex datasets into visual representations that are easy to comprehend. Moreover, data visualization could empower individuals to explore data interactively, fostering a deeper understanding of the information presented. In the context of smart cities and urban challenges, it serves as a medium for conveying the implications of data-driven insights (Kitchin, Lauriault and McArdle, 2015).

According to Kitchin, Lauriault and McArdle (2015), data are epistemological units with diverse representational forms derived from various methods of measurement and recording. For the authors, initiatives involving indicators, benchmarks, and dashboards inherently embody normative notions about what should be measured and why, influenced by various values. They believe that when people play a central role in data gathering, it should assume an objective method to produce transparent, impartial, and bias-free data.

D’Ignazio and Klein (2020) underscore that the neutrality often embedded in data visualization excludes emotion, affect, embodiment, expression, embellishment, and decoration, elements associated with the human experience, traditionally linked with women, perpetuated by ingrained stereotypes. Per Lupi (2017), as data becomes increasingly ubiquitous, the imperative is to explore methods to make it unique, contextual, and intimate, and the key to achieving this lies in how we visualize data, translating numbers into relatable concepts. Presenting data as part of a narrative makes it more accessible, memorable, and actionable. Data storytelling is a form of persuasion, employing data, narrative, and visuals to help an audience see something in a new light (Dykes, 2020).

Storytelling goes beyond presenting facts and figures; it inspires action and nurtures empathy. Lupton (2017) argues that design is storytelling. The author suggests that empathy enables people to work together and construct societies for

mutual benefit, essential for human civilization and is the linchpin of user-centered design. In urban challenges, storytelling clarifies the real-world impact of data, adding context and depth to make urban issues relatable and compelling.

According to the Design Council (2021), design is critical in building a bridge between technological research and innovation. For them, one characteristic of change-makers is to be a storyteller who can tell a great story about what might be possible and why this is important. These storytellers need to negotiate the disparate values of multiple stakeholders to identify shared values on which to work.

Participatory processes lie at the heart of citizen-centric design and compelling storytelling. Engaging citizens, stakeholders, and experts ensures that diverse perspectives are considered (Dittmar *et al.*, 2021). In addressing global challenges, design can combine diverse insights and experiences through storytelling, enriching participatory processes (Design Council, 2021). Involving the community in data-driven narratives enhances the relevance and impact of design solutions (Dykes, 2020).

Digital media has introduced tools that broaden the array of participatory techniques, including crowdsourcing platforms, augmented reality visualizations, and sentiment analysis, as emphasized by Meroni and Selloni (2022). Despite this, the authors caution that the full potential of these tools remains unexplored and requires evaluation. Leveraging digital tools for data visualization proves to be a viable ally in transferring knowledge within co-creative processes, as highlighted in the context of people-centered smart cities (Ziemer, 2021).

Soares and Cipolla (2022) emphasize that issues interconnecting storytelling with service design are emerging themes. For them, the act of telling and listening to stories is a simple innovation tool that can be applied at various stages of service development, promoting social well-being through collaboration. The authors propose for future research to develop methods that support storytelling as the primary tool for creating innovative services that drive social change by incorporating local knowledge. This thesis delves into this relationship, incorporating data narrative within a proposed participatory process. We believe that design can enhance access to extensive mixed urban data, often underutilized, through data storytelling. This led us to explore methods for gathering data and facilitating collaborative analysis by employing data visualization tools, ensuring transparency and comprehensibility in presenting information.

4.
Identifying challenges and solutions in big data and citizen participation projects

From the literature review, we observed difficulties in effectively utilizing all generated urban data. Additionally, engaging the population to participate in urban projects is also a tough issue. Therefore, the specific objective of this chapter is to identify challenges and solutions in projects involving big data and citizen participation.

In the initial section, we examined publicly accessible reports from European urban mobility projects. Subsequently, we outlined the outcomes of numerous interviews held with seasoned professionals engaged in projects of similar nature. These insights serve to validate the techniques employed for data collection and analysis in the upcoming phase.

4.1.
Civitas: Content analysis of mobility projects

How can we effectively combine citizen participation processes with data utilization for urban mobility in smart cities? To address this question, we conducted a content analysis of nine projects spanning over 50 cities. Our examination focused on projects that leveraged data to enhance mobility experiences, exploring the potential for automating demands through data integration. Drawing from the project reports, we showcase examples of solutions within the human factors domain that could apply to various projects.

This section introduces the research question by delving into specific attributes of real projects. The themes derived from the content analysis are structured using a Work Domain Analysis (WDA) approach. WDA scrutinizes the functional structure of actors' physical, social, or cultural environment within a system, shedding light on the constraints influencing their behavior (Naikar, 2016). This method proves effective in describing and comprehending cities as intricate systems.

4.1.1. Methodology

Based on the concepts previously discussed, we analyzed urban mobility projects, considering how they used data and the citizen-centered design processes. The chosen method was content analysis, systematically examining the form and content of written, spoken, or visual materials in themes, patterns, and counted occurrences of words, phrases, images, or concepts (Hanington and Martin, 2012). It is a well-established technique to systematize qualitative data, a method employed in this study due to the ample resources available.

The selected projects are part of the Civitas initiative by the European Union, a program that has been testing and implementing approximately 800 measures and solutions for urban transportation in over 300 cities since 2002. These mobility projects integrate technology and community participation. For this study, we chose research projects exploring the viability of technologies, products, processes, services, or solutions. These projects employed diverse methods and involved interdisciplinary partners to discover mobility innovations. From the 30 ongoing research projects, we selected those completed by September 2021, the date of our analysis, specifically within the thematic area of "Public Participation & Co-creation," totaling nine projects (Table 2).

From the extensive repository of almost 5,000 documents available on the Civitas website, we specifically focused on the reports of nine projects relevant to this study, totaling 23 documents and comprising 1,171 pages. Embracing an inductive approach to content analysis, our methodology involved a systematic reading of a sample set of texts to extract categories or codes that will be used for subsequent analysis. As recurrent key phrases emerged, constituting a common theme, we assigned a name characterizing it. Subsequently, we categorized examples of words representing that theme, gradually establishing the foundation for the subsequent analysis of all the materials (Hanington and Martin, 2012).

Initially, we managed the reports using the Notion application (Figure 5), and then we highlighted the codes with QDA Miner (Figure 6), an open-source qualitative data analysis software. We examined topics related to data and citizen participation, and we clustered our findings into areas derived from the initial systemic reading. These categories correspond to challenges, such as big data, engagement, and communication, along with potential solutions, including

crowdsourcing, social media, artificial intelligence, gamification, data visualization, co-design, and prototyping. Additionally, we identified issues in each solution, discussing difficulties in integrating human factors in urban design.

PROJECTS	ABOUT	DURATION	CHALLENGES	SOLUTIONS
CIPTEC (Collective Innovation for Public Transport)	Increase the modal share of public transport by understanding and attracting new users at a low cost	2015 - 2018	Big data, Citizen engagement	Crowdsourcing, Co-design, AI, Social Media
Cities-4-People	Make transportation more sustainable, people-oriented, and accessible. With locally designed mobility solutions, into participatory urban planning	2017 - 2020	Big data, Citizen engagement, Communication	Co-design, Prototyping
City Changer Cargo Bike	Exploit the potential of cargo bikes by promoting their usage amongst public, private, and commercial users	2018 - 2021	Big data	AI
Empower	Reduce the use of conventionally fueled vehicles in cities by influencing the mobility behavior of drivers and users toward fundamental change	2015 - 2018	Big data, Citizen engagement, Communication	Social Media
Metamorphosis	Transform neighborhoods into more liveable shared spaces, with the representation of children as a key indicator of a well-designed and sustainable neighborhood	2017 - 2020	Citizen engagement, Communication	Co-design, Gamification
MUV (Mobility Urban Values)	Improve mobility habits by gamifying urban commuting at the neighborhood level	2017 - 2020	Big data, Citizen engagement, Communication	Crowdsourcing, Social Media, AI, Gamification, Data visualization, Co-design, Prototyping
Prosperity	Support authorities to improve the quality of mobility, focusing on places where historically rates had been low	2016 - 2019	Big data, Citizen engagement	Crowdsourcing, Social Media. Co-design
SUMPs-Up (Sustainable Urban Mobility Plans)	Enable mobility planning authorities to embrace SUMP, especially in countries with low uptake and badly impacted by the negative effects of transport	2016 - 2020	Big data, Citizen engagement, Communication	Crowdsourcing, Co-design, Prototyping
Sunrise	Turn the co-creation approach into a tool to develop, implement, and assess novel transport solutions at the neighborhood level	2017 - 2021	Big data, Citizen engagement, Communication	Crowdsourcing, Social Media, Gamification, Co-design, Prototyping

Table 2 – Nine Civitas research projects analyzed in this study.

Despite having thoroughly examined a vast amount of material, this analysis has some limitations since we just read the reports available on the Civitas website

and does not necessarily cover all aspects of the projects. Maybe some cases could have challenges or solutions that we did not highlight because the materials did not report them. Also, some projects are older than others and have fewer resources online. Furthermore, we analyzed some reports showing an overview of many projects, not specifying each one, but we still used these references.

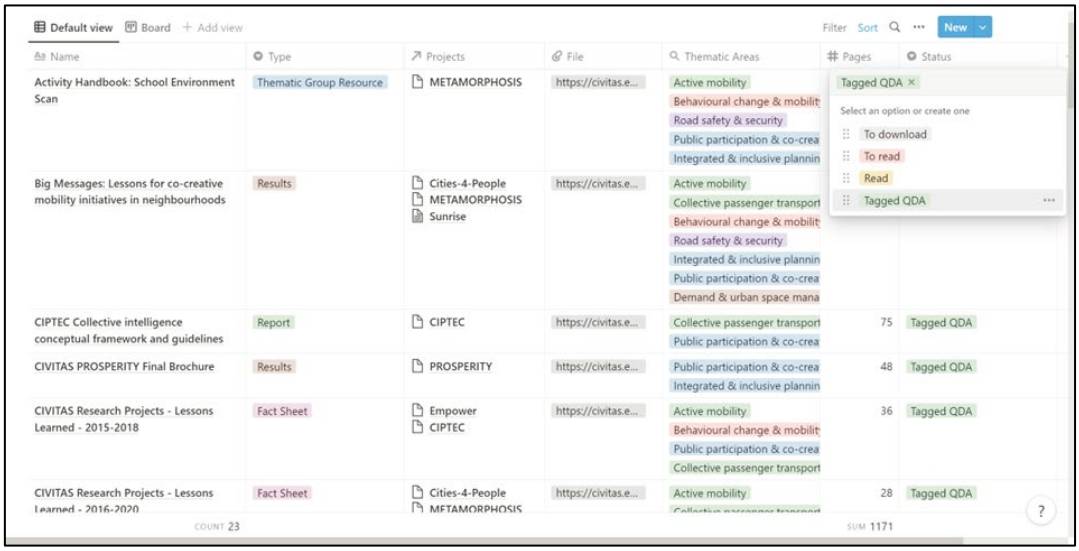

Figure 5 – Notion to manage the reports.

Initially, we imported all reports into QDA Miner and created a case for each project. When reports covered more than one project, a general case was established. Subsequently, we thoroughly read the texts and highlighted the previously identified categories. Each code had subcategories, initially grouped into solutions, tools, and challenges. As we progressed in our reading, the need arose to create new subcategories for emerging themes. Some sections of the reports discussed multiple topics, prompting us to assign multiple categories accordingly. For analysis, we conducted searches by filtering through the codes, and after a comprehensive review, we organized the key themes that proved most relevant to the study.

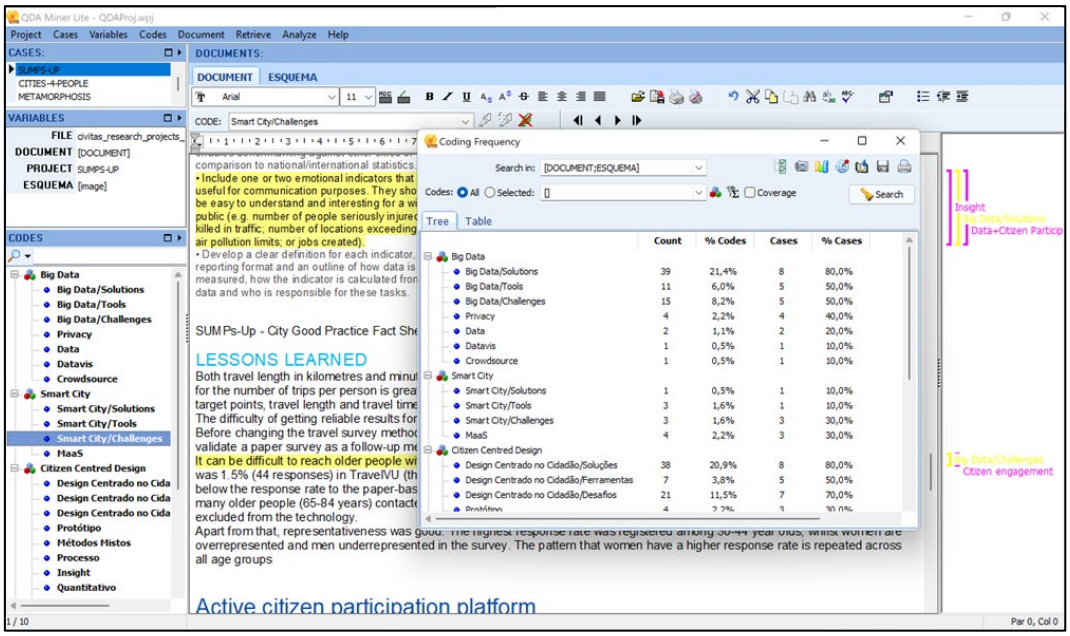

Figure 6 – QDA Miner to categorize and analyze.

Following this initial exploratory phase, we systematically organized the identified categories using a WDA approach. The WDA approach represents the first phase of the Cognitive Work Analysis, an HFE systems method (Vicente, 1999). This method yields a model detailing the activities within a system, elucidating the how, why, and with what they are conducted. The process is divided into five levels of an Abstraction Hierarchy: Functional purpose, Values and priority measures, Purpose-related functions, Object-related processes, and Physical objects.

According to Stevens, Youssef and Salmon (2019) the first step in constructing a WDA model involves defining the system, in this case, the Urban Mobility Projects. Next, we should identify and use various data sources, we developed with data derived from the Civitas reports. Then, the model is systematically constructed including keyword nodes at each level from content analysis categories. For the authors, once functional purposes, values, and priority measures are described, it becomes easier to include the types of physical objects and purpose-related functions needed. Table 3 provides prompts for inclusions at each WDA hierarchy level, aiding both data analysis and determining what data to include. We then refined the analysis, by an iterative process, establishing links between nodes across each level. Additionally, we colored the challenges and solutions topics in red and blue, respectively (Figure 7).

WDA HIERARCHY	PROMPTS	KEY WORDS
Functional Purpose	For what reasons does the system exist?	-purpose, goals, aims, objectives, rationale.
Values and Priority Measures	What criteria establish if the work domain is achieving its purposes?	-measures, results, targets, laws and regulations, standards, criteria.
Purpose-Related Functions	What functions are required to achieve the purposes of the work domain?	-function, roles and responsibilities, maintenance, tasks, activities
Object-Related Processes	What processes are the physical objects in the work domain used for?	-uses, components, processes, limitations, capacity.
Physical Objects	What are the physical objects or resources – both human-made and natural?	-tools, equipment, infrastructure, fittings, facilities, layout, buildings, assets.

Table 3 – Example WDA prompts

Source: Stevens, Youssef and Salmon (2019)

4.1.2. Results and analysis using WDA for urban mobility projects

This study identified critical capability criteria highlighting and categorizing the strengths and weaknesses of the approaches for citizen participation in urban mobility. An outcome is a framework that seeks to optimize the beneficial features of various data modes while minimizing their perceived weaknesses for citizen participation and urban mobility decision-making.

Many categories have challenges and solutions that fit with other topics. This model represents this relationship. The first layer is the functional purpose, which is why the system exists. We established three functional purposes for mobility in a smart city: Sustainable Mobility, Smart Mobility, and Human Mobility. These purposes are directly related to the aim of the analysis: the challenges of integrating big data with citizen participation.

The second layer encompasses values and priority measures crucial for quantifying our purpose. We have defined six key measures: more effective policy-based, more efficient mobility, optimize big data, more accessible information, increase citizen participation and improve the passenger experience. Among these measures, we highlight three pivotal challenges: harnessing the potential of big

data, fostering citizen engagement, and enhancing government communication strategies with the population.

The third layer comprises purpose-related functions. This model has defined 17 functions aligned with various objectives. In this endeavor, we have aggregated the categories, resulting in the grouping of:

- **Mobility-related functions**- integrating transport planning and changing in real-time based on the demand;
- **Data-related functions** - data collection and regular monitoring, measuring impact and implementing concepts, testing or evaluating the potential of solutions;
- **Communication-related functions** - alerting users about delays and issues in public transport, providing feedback and statistics about travel habits, influencing citizen behavior, and raising citizen awareness on sustainable mobility;
- **Engagement-related functions** - incentivizing users, flat the relations between citizens and public institutions, building a stronger collective memory, collaborating with other community initiatives, calling for ideas and opinions;
- **Experience-related functions** - tracking problems, suiting specific preferences, and learning the communities' and stakeholders' needs.

This level is arguably the most significant, as these functions bridge the strategic and goal-oriented levels (above them) with the physical resources and processes (below them) of the system (Tavares and Stevens, 2020). This layer connects the highlighted challenges with the solutions found in the projects.

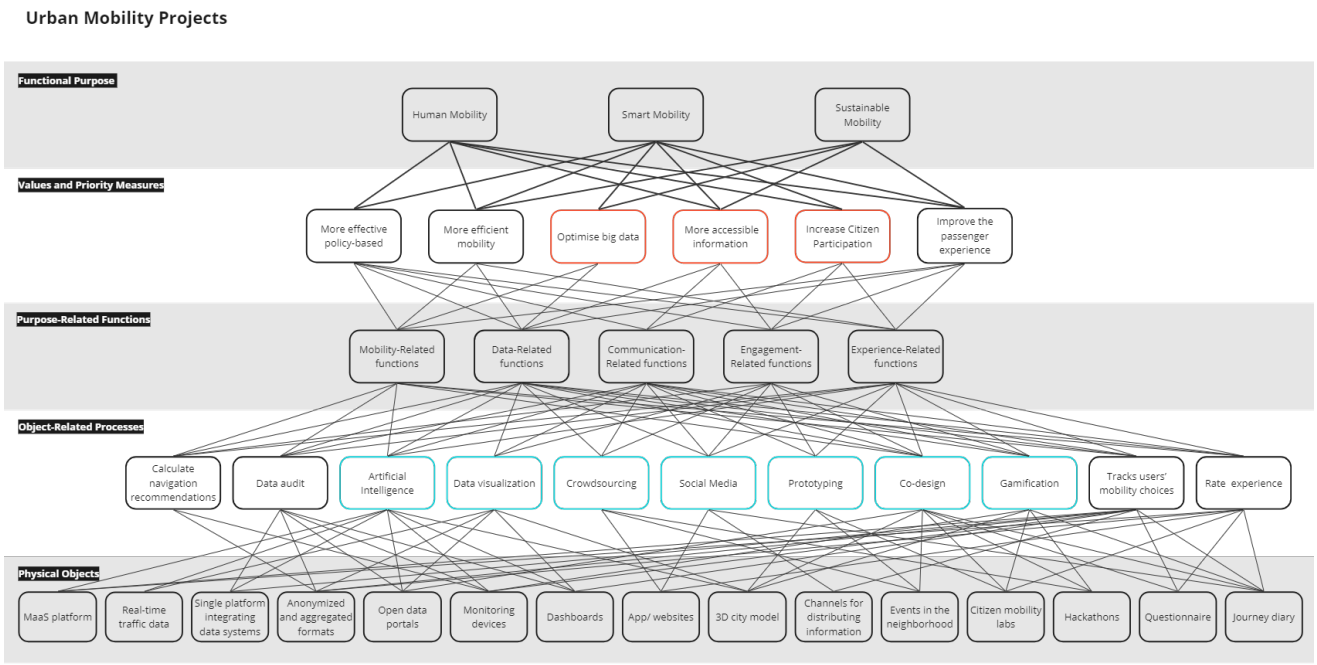

Figure 7 – WDA model of urban mobility projects

The fourth layer consists of object-related processes that operationalize the functions from the level above. Across the analyzed reports, we identified 12 processes. Among these, we highlighted the seven most relevant that will be further detailed in the following sections: artificial intelligence, data visualization, crowdsourcing, social media, prototyping, co-design, and gamification. These solutions were employed by various projects and offer valuable insights for our continued exploration.

The final layer is physical objects, encompassing 15 elements: MaaS platform, real-time traffic data, single platform integrating data systems, anonymized and aggregated formats, open data portals, monitoring devices, dashboards, apps/websites, 3D city model, channels for distributing information, events in the neighborhood, citizen mobility labs, hackathons, questionnaires, and journey diaries. Each element can facilitate multiple processes; for example, dashboards can enable Mobility as a Service, provide data visualizations, and be enhanced by artificial intelligence.

Table 4 illustrates the relationships between the 17 functions on the y-axis and their respective groups and the 12 processes on the x-axis. It identifies the connections established within the WDA model and highlights in gray the seven

solutions previously selected that we will elaborate upon in the following sections. This table underlines the relationship between these concepts and helps to understand the research's findings for use in other projects.

	PURPOSE-RELATED FUNCTIONS																	
	Mobility-Related functions		Data-Related functions			Communication-Related functions				Engagement-Related functions					Experience-Related functions			
	Integrating transport planning	Changing in real-time based on the demand	Data collection and regular monitoring	Measuring impact	Implementing concepts, testing or evaluating solutions	Alerting users about delays and issues in public transport	Providing feedback and statistics about travel habits	Influencing citizen behavior	Raising citizen awareness on sustainable mobility	Incentivizing users	Flat the relations between citizens and public institutions	Building a stronger collective memory	Collaborating with other community initiatives	Calling for ideas and opinions	Tracking problems	Suiting specific preferences	Learning the communities and stakeholders' needs
OBJECT-RELATED PROCESSES																		
Calculate navigation recommendations	x	x	x	x		x		x	x						X	X	X
Data audit	x		x	x		x	x								x		x
Artificial Intelligence	x	x	x	x		x	x								x	x	x
Data visualization			x	x	x		x	x	x		x						
Crowdsourcing			x	x	x		x			x	x		x	x			
Social Media			x	x	x	x	x		x		x		x	x	x	x	x
Prototyping					x				x		x	x	x		x	x	x
Co-design	x			x	x		x	x	x	x	x	x	x	x	x	x	x
Gamification			x	x		x	x	x	x	x	x			x	x	x	X
Tracks users' mobility choices	x	x	x	x		x	x	x	x						x	x	x
Rate experience		x	x	x			x								x	x	x

Table 4 – Relationship between functions and processes highlighting in gray some solutions.

The upcoming sections delineate the challenges encountered in the Civitas projects, shedding light on specific solutions that garnered prominence in the analyzed reports. After each category, we revisit the key insights gleaned from the respective topic, encapsulating the primary learnings derived from the examination of these initiatives.

4.1.2.1. Challenges for big data and citizen participation in urban mobility

In this results section, we explore the challenges linked to big data and citizen participation in urban mobility projects. These challenges are organized into three main themes: big data, citizen engagement, and communication. Each theme encapsulates insights derived from the challenges, offering a concise summary to inform future projects.

Big data

The projects emphasized the importance of prioritizing data collection and regular monitoring, real-time traffic data for integrated transport planning, and a more effective policy-based. Due to the wide variety of information and evaluation methods, it can be difficult to establish general trends, so a unified typology is needed: a single platform integrating data systems.

First, the city should perform a data audit to identify available information. Then, they get an overview of sources, identify available data, and assess their quality and accessibility. Sometimes, the resources for data collection are minimal, so just one department lacks data on many aspects. Therefore, mapping the data from other organizations in anonymized and aggregated formats to share with partners is helpful.

The MUV project organized data into three categories: participant data aimed at understanding the communities' and stakeholders' needs; data of expert systems employed to raise citizen awareness on sustainable mobility choices; and data for evaluation utilized to measure real impact. These data sources originate from various channels, including open data portals from the municipalities, the MUV application, social media data, and monitoring stations established within the MUV project.

Monitoring devices play a crucial role in comprehending the dynamics of urban mobility, offering insights into traffic flows, blockages, passenger numbers,

asset conditions, or broader events that could affect system performance. Such information enables real-time changes based on the demand to optimize the system's capacity. Another illustrative example of leveraging data for demand-driven optimization is found in the CIPTEC project. Here, a crowdsourced platform used location-based services to identify the origin of ideas, allowing for a detailed comparison with the particular circumstances of each location.

As indicated in the analyzed reports, several projects used the term "Mobility as a Service" (MaaS). They believe that implementing MaaS increases public transportation usage and enhances overall performance and efficiency. While MaaS promises an enhanced mobility experience for citizens, implementing it has many challenges. For example, the SUMPs-UP project encountered difficulties engaging mobility operators to integrate their platforms into a MaaS system. These operators are already established in the urban territory, with their platform having a consolidated user base. The main concern is the fear of losing customers by allowing the MaaS platform to act as an intermediary in selling mobility tickets, especially when competition exists on the same platform.

The SUMPs-Up project highlighted another issue related to data quality concerning modal share or traffic flow. This challenge arises due to the diverse data sources from various entities. Organizers collected baseline data during the projects, including CO2 emissions, modal shares, and shifts from cars to public transport. However, after the project's conclusion, the municipality lacked a structured data collection system to check improvements against these reference points, creating difficulties in reporting progress. This issue raises concerns for cities in managing and evaluating sustainable mobility initiatives.

Key learnings from the analysis of big data in the Civitas projects for future endeavors: integrating transport planning, data auditing, data collection and regular monitoring, real-time traffic data, anonymized and aggregated formats, and single platform integrating data systems.

Citizen engagement

Co-design, with civic participation, poses the challenge of effectively engaging individuals in this process. The projects brought forth several issues linked to the engagement challenge, including whether the expected contributions were perceived as too demanding, the timeframe was considered unrealistic, potential contributors were not adequately approached, the anticipated benefits

were not explicit or attractive enough, signals of appreciation were unclear, and if the concerns of potential contributors were not well understood and addressed, among other considerations.

The MUV project encountered challenges in maintaining consistent engagement from citizens using the app to register sustainable mobility choices. To address this issue, they sought more effective strategies, including special training sessions in each cycle. Unfortunately, the overall result was negative, indicating the need for additional and intensified efforts.

The main challenge lies in effectively engaging citizens to participate in these projects. In the Cities-4-People project, the time constraints during meetings pose a problem, impacting the reach of participants and making it challenging to develop comprehensive concepts within a short implementation schedule. Another project facing time-related issues is Metamorphosis, which involves working with children. Given children's limited attention spans, planning shorter sessions with more stimulating activities becomes essential to ensure meaningful participation.

Simplifying the project can be more effective in managing all proposed activities. For instance, in the SUMPs-UP project, conducting a well-executed workshop in one or two steps was more beneficial than attempting to engage the public too often and risking participation fatigue. Another solution, as seen in the MUV project, is using online hackathons. This approach proves valuable for gathering input from individuals who might not usually participate in other activities.

Co-design activities are resource-intensive, requiring both time and financial investment, and any new project will take time to attract participation. The Sunrise project enhances engagement by capitalizing on events in the neighborhood where people already gather. Therefore, collaborating with other community initiatives becomes a valuable opportunity, especially in the early stages of the process.

Another strategy employed in the Cities-4-People project to attract people's attention involves confronting taboo topics. Using this communication approach can prove effective, especially when the community has a keen interest in the subject. For example, the parking issue is a polemic topic, with some commercial establishments advocating for it and other entities favoring more walkable cities. This controversy sparks interest and prompts various parties to share their perspectives and engage in discussions. Leveraging such contentious topics

becomes a means to involve individuals with solid opinions in co-designing potential solutions.

Key learnings from the analysis of citizen engagement in the Civitas projects for future endeavors: making simple projects, online hackathons, collaborating with other community initiatives, events in the neighborhood, and confronting taboo topics.

Institutional communication

A potential reason for the limited citizen participation is attributed to non-transparent communication. When past implementations fail to meet expectations and are not communicated transparently, it can lead to demotivation among the public. Additionally, project and participation fatigue may arise from multiple participatory activities that lack visible results. Striking the right balance is crucial to fostering a culture of participation without overwhelming individuals with too many projects.

The project reports emphasize that participants in the co-design process may become disillusioned if they perceive that their input has not led to tangible outcomes. Therefore, it is essential to manage expectations and avoid making unfulfillable promises. Keeping participants informed not only enhances transparency but also instills a sense of control. Additionally, the reports underscored that citizens, policymakers, and researchers have different agendas, necessitating transparent communication characterized by openness and honesty about these differences.

Effective communication plays a pivotal role in fostering better engagement. Therefore, it is essential to have continuous information during the entire participation process. For instance, in the Sunrise project, establishing channels that effectively reach the target groups with informative material is crucial. While activities contribute to raising awareness and interest, the process may be lengthy. Therefore, ensuring that individuals have a means to stay connected with the project is of utmost importance.

Some reports related that the volume and complexity of communication materials were vast, making it almost impossible for both decision-makers and citizens to gain a clear overview and understanding of the project's broader impacts. This led to an increased number of complaints and extended processing times. Therefore, addressing the communication challenge, akin to the previous issue with

big data, requires materials to be accessible to the target group using plain language.

Likewise, it is vital to identify the proper channels to reach the community. For example, in the Sunrise project, individuals less familiar with technology engaged through an activity at a familiar club, proving more effective than using an online platform. Utilizing a combination of online and offline tools allows for the involvement of different citizen groups. Since there is not just one way to reach everybody, the communication must be tailor-made for each target audience.

Another challenge involves citizens' distrust when external partners lead a co-design process, as they may be seen as outsiders. As suggested by the reports, a potential solution could be investing in relationships between local anchors to reduce doubts from public authorities. NGOs, businesses, or schools might facilitate this process since citizens already know them. Also, it is crucial to ensure that project results will be implemented and demonstrate how decision-makers take up the process's results. The communication should provide evidence of how the participation process was materialized.

Key learnings from the analysis of communication in the Civitas projects for future endeavors: transparent communication, participation fatigue, managing expectations, continuous information, channels for distributing information, plain language, a combination of online and offline tools, and relationships with local anchors.

4.1.2.2. Solutions for big data and citizen participation in urban mobility

The solutions presented in the following sub-section have been extracted from the Civitas project reports. These solutions were inherently embedded within the project documentation, and we categorized and synthesized them. Organizing these solutions intends to offer a comprehensive resource that other projects can readily leverage, facilitating the application of insights derived from the Civitas initiatives in their own contexts.

Crowdsourcing

One form of data collection identified within the reports' analyses is crowdsourcing, which the CIPTEC project defined as outsourcing a function to an undefined network of people. Crowdsourcing has been used for many tasks, such as gathering data, developing new content, generating innovative ideas, and raising

funds. It has emerged as a method for generating innovative solutions for corporate and societal issues. This collaborative approach can make mobility more sustainable for policymakers. However, it requires storing data in online repositories for easy access by various parties.

Data from geo-referenced crowdsourcing has grown and plays a crucial role in citizen participation. Applications that allow users to rate their experience while moving along a route may calculate navigation recommendations to suit specific preferences. The CIPTEC project employed crowdsourcing to call for ideas and opinions, enriching the available resources. However, the ideas collected from crowdsourcing may not always be viable or align with the project's scope. For example, participants in the SUMP project offered minimal proposals and comments related to policy issues and project goals.

Many online tools have the disadvantage of not informing who participated. Also, there is a risk that the crowdsourced solution would not represent its society mix, as not all users have enough technical skills to engage in collaborative online processes. For example, the Sunrise project encountered challenges in reaching older people, groups with no access to the internet, or those unfamiliar with computer usage and facing digital literacy barriers. The CIPTEC project reported that this factor could negatively impact the project's success.

Another challenge lies in engaging participants actively in the use of crowdsourced tools. Without broad citizen participation, the data collected might be limited to a minority of users, diminishing the potential for valuable insights. Promoting a new online service faces challenges due to intense competition, making it difficult to attain a critical mass of users. However, the smaller number of participants can still offer valuable insights. The MUV project advises leveraging existing popular platforms, such as Facebook groups and Instagram accounts, rather than creating new tools.

Key learnings from the analysis of crowdsourcing in the Civitas projects for future endeavors: geo-referencing supports citizen participation, user-rated experiences, possibility to calculate navigation recommendations, suiting specific preferences, source of ideas and opinions, representative mixes, and promotion of services.

Social Media

Facebook, Instagram, X, YouTube, Flickr, and TikTok are examples of

platforms that allow diverse communities to discuss their needs and positions without significant access barriers. Also, these social media can be channels for distributing information publication. Content generated in these tools can be interactive, evolving ideas and needs through public commenting, editing, and voting of entries.

The MUV project analyzed social media sentiment based on public tweets targeted with specific hashtags. This strategy had valuable input, with a relevant discussion resulting from the activities organized by the project. However, social media data extracted from public network interaction, as identified by the MUV project, has a non-structured text format, making it more complex to store and analyze.

Social media channels have the potential to address the person identification issue reported in crowdsourcing platforms by displaying user interactions. However, for the Sunrise project, it is crucial to consider local data protection laws, as this information can be sensitive. Additionally, the rise of users with false profiles, sharing misinformation, or making spam contributions poses a challenge. Some participants may prefer to remain anonymous, potentially leading to interactions with fake profiles.

Key learnings from the analysis of social media in the Civitas projects for future endeavors: without access barriers, interactive, sentiment analysis, non-structured data, privacy, and fake profiles.

Artificial Intelligence

Although some projects mention artificial intelligence in their reports, it remains a relatively unexplored field. Examples of AI applications include monitoring mobility patterns by an AI specialist and utilizing AI with crowdsourced data, akin to platforms like Waze and Moovit. AI technology is employed to detect map errors, confirm blockages, road closures, predict public transit or arrival times. Notably, the CIPTEC project used an algorithm to retrieve some ideas from their crowdsourcing platform, selecting the most popular ones before each workshop based on specific criteria, such as rating, views, and comments.

An interesting example of AI is the CityMapper tool, as mentioned by the MUV project. This tool not only alerts users about delays and issues in public transport but goes beyond simple warnings. The AI integrated into the application reads alerts issued by local travel authorities and translates these into user-friendly

notifications and clear route changes. This solution leverages technology to enhance the accessibility of information, addressing one of the main challenges in using urban data for citizens.

Key learnings from the analysis of AI in the Civitas projects for future endeavors: monitoring mobility patterns, retrieving data from crowdsourcing platforms, and translating information.

Gamification

One of the objectives of this thesis is to investigate the potential of translating big data for the general population. A strategy employed in several projects is gamification. For example, the MUV project tracks users' mobility choices through an app. They provide feedback and statistics on travel habits, enabling users to challenge each other. Players can also collect trophies and redeem physical rewards and discounts from local sponsors, incentivizing individuals to use the application. The most virtuous and frequent users of the app receive monetary awards.

An appealing feature involves comparing measures to give shape to the analyzed data. For example, in the SUMPs-UP project, the distance traveled, and the sustainability of transport means were calculated based on emission savings from car-based trips. Users received points equivalent to the number of trees required to absorb the CO2 produced by each trip. This approach makes it easier to comprehend the impact of their behavior, providing a visual representation with images of plants rather than just numerical data.

The Empower project also uses tracking data to influence citizen behavior. The most popular features available were traffic information and tracked travel statistics. Thus, the data additionally deliver value to the user, increasing engagement and encouraging participation.

Key learnings from the analysis of gamification in the Civitas projects for future endeavors: incentivizing users, providing feedback and statistics about travel habits, and comparative measures.

Data visualization

Data visualization can be used as a tool to democratize access to information. Open data can be reached through dashboards, as demonstrated in the MUV project, where these dashboards serve not only as tools but also as systems to flat the relations between citizens and public institutions. They facilitate a dialogue with the community and provide easy access to data that has already been collected and

processed. Even a data-driven approach can serve as a basis for meaningful conversation and action. The Sunrise project raises a significant concern regarding data bias in presentations and how it can affect people's perception of information. Therefore, data should be visualized in easily understandable formats for citizens and policymakers, ensuring a neutral presentation that is mindful of the conveyed message.

A participative process could offer a solution to this issue. For example, the MUV project uses co-design sessions to analyze the community's needs and develop dashboards. These user research activities help gain a deeper understanding of how to design web dashboards, identify the data users are interested in, and determine the most effective ways to present it.

An innovative case of visualization, as reported in the MUV project, is the 3D city model of Helsinki, which permits many ways of interaction with stakeholders. It is not just a 3D picture, but it is a 3D semantic database of the city. For example, the government could implement a new development in a 3D model, and at the same time, the public can observe and interact with it freely. The model is converted into a format accessible to game developers, unlocking numerous visualization possibilities.

Key learnings from the analysis of data visualization in the Civitas projects for future endeavors: dashboards, easily understandable formats, and 3D city model.

Co-design

Some projects used citizen mobility labs to implement concepts and test or evaluate the potential of various solutions. These labs served as collaborative spaces, bringing together citizens, government representatives, industry stakeholders, and research partners to co-create new policies, regulations, or actions. For example, the Cities-4-People project creates citizen mobility labs, workshops, and prototyping activities to co-identify the challenges, co-select the areas of intervention, and propose and co-design diverse solutions to address mobility-related issues.

The CIPTEC project validates and evaluates idea gathering from crowdsourcing with co-creation workshops. Likewise, the Sumps-Up project utilizes an interactive city map to submit suggestions. That way, it increases citizen participation and provides constructive proposals.

A notable challenge lies in capturing intangible data like quality and innovativeness. The Cities-4-People project distributed a questionnaire before and after the pilot implementation to measure the impact of the intervention. The CIPTEC project cited another example, the 'train journey diary.' Participants recorded their trips using this approach, and researchers discussed the annotations with contextual interviews.

The Metamorphosis project conducted vision-building workshops with children, the project's main target group. In another activity, the municipal representatives, parents, and children walked together through the school environment, distributing TIPS and TOPS. This system provided participants with a means to communicate their opinions and thoughts about their surroundings to those who held the capacity to influence them.

The MUV project involved the local community in customizing the app. They co-created the user avatars, developing an exclusive visual identity. This process utilized a combination of real-life and culturally significant city figures. The personalized visual references contributed to an enhanced user identification with the app.

The CIPTEC project cautioned that workshops should avoid constraining participants by promoting specific behaviors or ideas, and the participant demographic should mirror the demographics of the public transport user base. CIPTEC also recommended that integrating workshops with input from an expert board ensures the involvement of both users and experts. Additionally, the Sunrise project emphasized the importance of engaging residents from disadvantaged areas who traditionally feel excluded from planning processes.

Key learnings from the analysis of co-design in the Civitas projects for future endeavors: citizen mobility labs, co-design workshops, implementing concepts, testing or evaluating the potential of solutions, a questionnaire to measure impact, train journey diary, and TIPS and TOPS.

Prototyping

Frequently, citizen participation processes employ prototyping as a tool. According to the SUMPs-Up project, pilot projects can precede and validate bigger ideas by introducing trials and demonstrations, allowing participants to "see it to believe it." Prototypes can spark interest and gain acceptance from end-users. The Cities-4-People project emphasized the benefits of adjusting implementation based

on users' preferences, thereby increasing their participation. Additionally, using a prototype to test new solutions and ideas alleviates the pressure for instant success.

An interesting prototyping solution is the case of the MUV project, where they organized a session featuring a demo version of an air quality sensor. Researchers installed a sensor in the room during this session, projecting real-time measurements on the wall. They demonstrated the sensor's functionality by manipulating dust, allowing technical experts and citizens to observe the corresponding changes in measured units. Following this demonstration, numerous participants expressed interest in installing a sensor in their homes, fostering an active community while providing valuable data. This example underscores how creating tangible prototypes or other physical points of reference can contribute to a stronger collective memory of co-creation sessions.

Key learnings from the analysis of prototyping in the Civitas projects for future endeavors: pilot projects, no pressure to succeed, demo sensor, and building a stronger collective memory.

4.1.3. Discussion

The ensuing discussion explores how a citizen participation process and data utilization can contribute to innovative solutions in urban mobility. Drawing upon the findings from the Civitas projects, this discourse aims to contextualize and elucidate the implications of these results within the existing body of literature. The growth of data (Kitchin, 2014), alongside the complexity inherent in the concept of smart cities (Stevens, Youssef and Salmon, 2019), underscores the importance of employing human-centered processes (Mulder, 2015b). It becomes evident that the outcomes of the Civitas projects align with the issues identified in the literature and contribute to discussions about solutions in this domain.

The final dashboard interface developed in the MUV project endorsed the concept of allowing free data exploration. This approach empowers users to show or hide information by selecting checkboxes associated with specific data items, offering a dynamic and customizable experience. Unlike a rigid narrative, this interface encourages users to craft their story by choosing parameters or navigating through time. Despite being a co-design solution, there is a potential drawback: this approach might overwhelm users with information, demanding more interest and

cognitive effort to grasp the data. As Spinillo (2023) warns about the unnecessary use of technological resources in data visualization, such as superfluous interactions that may lead to cognitive overload and even demotivation in accessing data. Therefore, it becomes crucial to understand the users, their interaction purpose with the data, and the optimal way to represent it for their goals.

The projects present solutions to improve sustainable mobility in various cities. However, there are many challenges in urban data subjects, such as the SUMPs-Up project, with issues like the lack of technical expertise among professionals. They created workgroups for data evaluation with academic or private partners to address this challenge. Xu (2019) argues that human-computer interaction practitioners should proactively engage in artificial intelligence research to increase their influence, learn about AI, and integrate methods, fostering practical cooperation. As demonstrated in SUMPs-Up, these workgroups also serve as a valuable avenue for learning about artificial intelligence, contributing to an enhanced utilization of urban data in human factors design.

Additionally, many cities have been faced with insufficient data available. The SUMPs-Up project used qualitative rather than quantitative methods to get around this. Using various model approaches can lead to finding sustainable and effective solutions to complex problems (Salmon and Read, 2019). This integration creates insights that go beyond those generated by each method. The advantage is in neutralizing weaknesses by triangulating data sources (Creswell and Creswell, 2018).

Another challenge lies in privacy concerns; however, anonymized data from mobile cellular networks has proven effective in tracking population mobility, notably employed during the COVID-19 crisis (Cordeiro, Mont'Alvão and Quaresma, 2020). Even so, several projects underscored the importance of the leaders having enough time to verify how to perform the data collection in conformity with privacy and local laws. They must ensure that methodical and robust processes are in place for assessing and addressing ethics, data protection, and privacy issues, especially when working with children and other vulnerable groups.

The co-design process, as highlighted by Steen, Manschot and Koning (2011), has costs and risks of implementation. There is a cost of time with several people available and the risk of losing control as too many people participate, which

increases complexity. The authors believe that the more people work together, the more difficult it is to reach an agreement. So, how do we encourage stakeholder and citizen engagement in the development and execution of public policy? Some projects used gamification with a reward policy, but attention to the participants' impartiality is needed. Incentives may also be required in focus groups because of the difficulty setting up. While interviews are a more straightforward method, they incur higher transcription costs and lack the interactive group discussions characteristic of focus groups.

A relevant challenge for involving different stakeholders in the co-creation process is communication. A suggestion could be a persuasive narrative utilized by the MUV project, informing that participation allows users to shape mobility policy in their favor. The users expressed satisfaction in viewing their data used in the right way. Another interesting approach is to frame the action positively. The Metamorphosis project used the streets for children and called the activity "street opening" instead of "street closing." Also, it is valuable to communicate with emotional indicators, such as in the SUMPs-UP project that included the number of people injured or killed in traffic. This information should be easy to understand and attractive to the broader public.

For Frascara (2000), only the information in a message does not motivate people to act in each way, but a factor combination: the relationship of the values perceived in the communication with the public purpose, the source credibility, changes in legislation, and policy control. Despite this, a small group would be impossible to change. The author believes it requires identifying the subgroup that justifies a communication effort. The Sunrise project reached local stakeholders in regional forums, allowing cities to share activities and information. The Empower project leveraged the collected data to promote on social media and online networks, considering targeted advertising to previously identified audiences.

As emphasized by Creswell and Creswell (2018), a mixed-methods approach proves more effective, acknowledging the inherent weaknesses of individual methods. In this context, an integrated online and offline strategy is more robust since digital participation alone is insufficient. For instance, physical meetings facilitated dynamic face-to-face discussions in the Sunrise project, fostering community building and networking. Moreover, additional participatory tools can reach target groups excluded from online discussions during offline events. So,

combining online and offline dialogue should coexist in co-design processes.

Finally, the concept of co-creative partnerships, articulated by Mulder (2018), ensures collaborative ownership with corresponding responsibilities. Inviting the citizens to know how to collect their data is effective because they have a sense of ownership. For example, the MUV project teaches the citizens how to install and use the stations in their homes and continuously reports on their findings. This proactive involvement fosters a positive acceptance, indicating the willingness to participate, learn, and contribute to the data collection.

4.1.4. Concluding remarks

The analyzed cases show a rich and vast area of mobility projects that use urban data and citizen participation. Different approaches could be referenced for replication in other contexts. However, there are some technological challenges, such as the lack of infrastructure, technical knowledge, interest, and engagement of different stakeholders.

Investment in citizen participation includes time, money, trust, effort, and commitment. Co-design with citizens takes longer than the traditional top-down approach. Artificial intelligence could solve some challenges, using the potential of machines to automate human work and extend the capacity for data collection and analysis. However, it can not be separated from the privacy discussion, although any new technology development must be unbiased, humane, and ethical.

In conclusion, nine projects were in the “Public Participation & Co-creation” thematic area. However, from these nine, just one was also in the area of “smart & connected mobility,” the MUV project. So, this case deserves further study in future research to understand how they integrate these two investigated topics.

The big data and co-design combination could expand the human factors field with more technological inputs and the humanization of urban data. By incorporating citizen participation into the research process, cities could become more human-centric and smarter. This study has synthesized key findings from the Civitas projects, highlighting specific solutions for urban mobility that could extend benefits to other research areas. These insights could contribute to generating more comprehensive and contextualized data, helping professionals, academics, governments, and citizens.

4.2.
Interviews with experts working in the field[3]

Using urban data is a complex process, and it is not uncommon that it is not combined with qualitative data, consequently losing the contextualization of the information gathered. Also, bringing citizens to participate in co-creating urban services is a challenge. To explore this hypothesis, we identified the issues related to citizen participation in real urban projects, by running semi-structured interviews across three European countries. Building upon the insights from the Civitas reports, we formulated questions to delve deeper into how professionals addressed these challenges. Our goal was to understand how they managed the data available and citizen participation, and which processes they applied to that purpose.

4.2.1.
Methodology

We conducted nine interviews to explore citizen participation and urban data and gather current challenges and assets in SD processes. The focus was recruiting professionals who have worked on projects with citizen participation. The projects had similar characteristics: for cities and with different types of stakeholders' involvement.

Participants signed a consent form (Appendix C) and the interviews were semi-structured. We gather information regarding their professional experience, workflow in the office, and specific project-related queries, followed by inquiries on challenges or suggestions regarding the SD process (see the base script in Appendix D). The interview questions remained consistent for all participants. However, during the study, the analysis of initial interviews revealed the need to include questions about the pandemic's impact on the workflow and projects of the participants. Therefore, we revised the script in subsequent interviews and included questions about online workshops, workflow, and project management changes in the pre and post-Covid-19 era.

All in-person interviews lasted about one hour and took place between August and October 2022 in Copenhagen, Berlin, and Oslo (Table 5). The interviews were

[3] This chapter was partially published under the following reference: CORDEIRO, R.; QUARESMA, M.; FRÓES, I. Issues integrating urban data and citizen participation. In: , 2023, Rio de Janeiro. ServDes. Rio de Janeiro: Linköping University Electronic Press, 2023.

conducted in the interviewees' work environment to gather insights about their practice and learn about their team. It was valuable, as the discussed projects often involved professionals in different sectors of the organization. One advantage of in-person interviews is the ability to observe physical tools used in their practice (Figure 8). Some meetings were individual, and others were in a group if the professionals worked together. The interviewees acted in universities or municipalities' partnering organizations.

SECTOR	CITIES		
	Berlin	**Copenhagen**	**Oslo**
Academia		5	1
Municipality	1	1	1
Total	1	6	2

Table 5 – Summarise the participants' characteristics

The interviewees who worked in academia were researchers acting in SD labs with projects focused on the city. The interviews covered aspects of their work and background research experience. They were professors or PhD students. The government sector participants did not specialise in SD but worked as project managers with service designers on the same team. Due to time and geographic limitations, we visited only three cities: Berlin, Oslo, and Copenhagen.

Berlin is the capital of Germany and has 3,570,750 inhabitants. As part of the "Smart Cities Model Projects" program, Berlin has developed a new smart city strategy focusing on participation, people, and social good. The plan highlights that it has not had a purely technological focus and instead has moved toward co-design and inclusion, actively dialoguing with Berlin's diverse urban society. With this idea, Berlin received funding from the Federal Ministry of the Interior to be a Smart City model project.

At CityLAB Berlin[4], the administration and urban society collaborate on developing solutions for the city guided by the principles of SD. They prioritise incorporating user perspectives early in their processes and employ agile, co-

[4] https://citylab-berlin.org/en/start/

creative, and user-centric methods to achieve their goals. The interviewee was the project manager responsible for Smart City and Participation area.

Figure 8 – A tool with urban data visualisation in the CityLAB Berlin

Source: Photo by the author

The second city visited was Oslo, Norway's capital, with 1,071,062 inhabitants. The European Commission awarded Oslo as the European Green Capital title for 2019. They measured 12 indicators, including efforts to reduce greenhouse gas emissions, improve the quality of air and water, environmental innovation, access to green areas, biodiversity, and green mobility. The Governing Mayor's Office set up a secretariat to plan and execute the year in cooperation with all municipal services, other public actors, academia, organisations, and the business community. The challenge was to make quick decisions while safeguarding the need for broad participation and ownership in all parts (The City of Oslo, 2019). The interviewee was the project manager responsible for this secretariat. In Oslo, we also talked with an academic from AHO, The Oslo School of Architecture and Design. Their research focuses on designing experience-centric services.

The third city was Copenhagen, often well-evaluated in smart city rankings,

with a good performance in mobility and environmental aspects (Ekman, 2022; ESI, 2018; Smart City Observatory, 2021). The capital of Denmark has 1,370,131 inhabitants and aims to become a carbon-neutral place (Lee, 2019). The interviewee was a strategic designer from Danish Design Center (DDC)[5], an organisation that has been in business for over 40 years. DDC believes collaboration is vital to eliminating the silos in the way of innovation. So, they design partnerships where companies and organisations work together across industries to drive green, digital, and social transformations with long-lasting results. In Copenhagen, we engaged in discussions with five professionals from the academic sphere at Aalborg University. They are associated with the Service Design Lab and have actively contributed to urbanism projects funded by the European Union, including those examined in the preceding section.

The semi-structured interviews were exploratory. As expected in qualitative approaches, the number of interviewees does not need to be excessive, as the research reached saturation after the sixth interview (Saunders *et al.*, 2018). Initially, we recruited individuals with experience in Civitas projects. As the interviews progressed, we employed a snowball sampling approach by seeking recommendations from participants, thus broadening the scope and diversity of perspectives (Lazar, Feng and Hochheiser, 2017).

We used a content analysis approach in the responses collected in this study. Content analysis involves systematically identifying and categorizing themes in qualitative data (Marsh, 2018). The Notion software facilitated the process of tagging and visualizing the insights. This tool allowed for a more structured and organized approach to analyzing the data collected from the respondents.

4.2.2. Analysis and discussion

We grouped the themes from the responses into categories, including accessible data, co-design, engagement, examples, futuring, gamification, service design, social media, and online workshops. In the subsequent sections, we organized the categories according to key findings: Accessible Data, Data in the Participatory Process, Lessons Learned in Pandemic Times, and Citizen Participation Engagement.

[5] https://ddc.dk/#

4.2.2.1. Accessible Data

Although there is a growing trend of opening digital data, it is often unstructured and difficult to interpret. Some researchers reported that data owners sometimes aggregate datasets without clearly understanding their potential use, as their primary focus is on addressing other issues. In alignment with Kitchin and Lauriault (2015), it is acknowledged that tackling the challenge of big data involves handling an abundance of data, including substantial volumes with limited utility, often generated without a specific query or as a by-product of other activities.

The DDC has undertaken a project to identify public data that could promote green values and encourage its use. Companies and data-owning authorities explored new possibilities for linking technology with public data. Despite different interests, the designer's role was to facilitate and translate this meeting to establish partnerships. The dialogues focused on addressing challenges and determining responsibilities and roles between public and private actors for future work.

Another challenge is selecting what kind of data is essential for that purpose. Sometimes projects involve several cities, and what might be helpful for one may not be valid for another. In this setting, it is necessary to use terminology that all participants understand and access the information. For example, one respondent desired a responsible mediator as an intermediary to oversee data handling and facilitate translation. This intermediary would bridge the gap between the party that generates and opens the data and the one that uses it.

The interviewees working in the public sector did not report this type of issue. The government is the one responsible for generating large amounts of data through its data collection services, thus being the leading owner of the dataset used. Their role in working for the government allows deeper access to the whole process. Consequently, the public workers interviewed described having easier access and a structured department to collect the necessary data. They work in a smoother partnership because these teams work on the specified tasks.

4.2.2.2. Data in the participatory process

Access to data is crucial for the discovery phase in a SD process. Therefore, we wanted to know how the interviewees used the data in the co-design workshops. One interviewee, who is a researcher, reported that before starting the workshop,

they first align the participants' knowledge, ensuring everyone is on the same page. Other respondents highlighted the importance of the dataset owner being present at the workshop so that they could clarify any doubts. At the beginning of the activity, the dataset owner presents the information and works with the groups.

Another way to make the data accessible during the workshop is to send some data before the meeting to help prepare the participants. Sometimes it is too much information to go through during the activity and sending it in advance is a way to familiarise the participants with the problem. However, this strategy can be ineffective when participants fail to review the information before the meeting, resulting in duplication of work and wasting time for other participants.

Despite this difficulty in making the data accessible and understood during the workshop, using data visualization techniques in the workshops is unusual. Some interviewees reported that they analyzed the data beforehand but presented it textually. One researcher highlighted the difference between raw data visualization in the research phase and mapping visualization in the analysis phase. These visualization tools are more common in the analysis than in the discovery process.

The Future City Game, mentioned by a participant, is an example of a collaborative process using data materialization. It is a two-day activity to generate ideas to improve the quality of life in cities. Teams identify common challenges facing the city, such as environmental, social, economic, and cultural issues, using a physical pie chart to divide the areas (Figure 9). They design solutions tested and refined with practitioners and community members (Kahn *et al.*, 2009). This approach enables participants to interact more tangibly with the data, fostering creativity and effective solution generation.

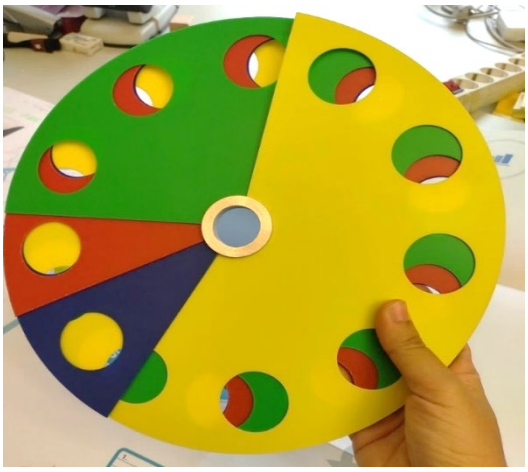

Figure 9 – Pie chart tool utilized in a co-design process
Source: Photo by the author

Furthermore, these manual tools are ways to facilitate learning. A well-known methodology is Lego Serious Play, where participants use LEGO bricks to create models that express their thoughts, reflections, and ideas. The creative process of making something prompts the brain to work differently and can unlock new perspectives. In addition, when all participants have a constructed object in front of them, they can set their issues on the table and have an equal standing ("Introduction to LEGO® SERIOUS PLAY®", 2020).

4.2.2.3. Lessons learned in pandemic time

Despite the utility of these tangible tools, the pandemic forced a shift from physical to virtual workshops. Most interviewees used the Miro[6] tool for online meetings as a digital adaptation of the face-to-face version. While the tool had some advantages, such as pre-digitized information, the process was still highly manual and time-consuming.

Regarding the DDC, the interviewee reported receiving training on optimizing the use of visual collaborative software through Miro boards. They went beyond replicating the face-to-face experience and created immersive narratives that guided participants through the boards, transforming them into virtual environments. As a result, they incorporated more rules, breaks, and reflections into the virtual workshop to ensure a smooth and engaging experience for all participants.

Virtual workshops offer another benefit: they can be conducted asynchronously, allowing each participant to take the time to assimilate the knowledge. The facilitators can also create surveys during the process and download post-its in text format. As the interviewee from DDC pointed out: "We can collect qualitative data in a more quantitative way".

Some people used Miro not only to carry out the workshop but also to visualize and analyze the data. They said they chose one tool or another depending on who was participating and the purpose of the analysis. They used more Miro when the audience was mainly composed of designers and sometimes an Excel spreadsheet to present the data to a business audience, for example.

Despite the availability of virtual collaboration tools, some researchers still

[6] https://miro.com/

prefer face-to-face meetings due to the perceived lack of human contact in digital environments. To address this issue, CityLab Berlin developed a strategy of complementing online sessions with two face-to-face meetings - one at the beginning of the project, for introductions and engagement, and one at the end for closure and celebration. Also, another researcher reported that the online workshop was not very productive; despite the advantage of having participants from several countries, sometimes they were not fully involved in the dynamics.

4.2.2.4. Citizen participation engagement

One common challenge reported is the difficulty of including and engaging participants. CityLab Berlin provided an example of how they addressed this by holding dinners to get more participation. Another researcher emphasized the importance of creating an appealing environment that would make people feel welcome and encourage them to participate.

The interviewee from Oslo Municipality explained that they engaged different stakeholders by taking advantage of neighborhood meetings to reach people who would not usually participate in such activities. Other interviewees reported success in attracting new participants in open-place events already happening in the cities.

There is a consensus among the interviewees that diverse and inclusive groups in society require different approaches and types of communication. It is essential to understand the motivation of each group, adjust expectations, and make the value of participation visible. CityLab Berlin provided an example of a project where they wanted diverse people to participate, so they contacted potential participants to understand what they needed. Sometimes, participants needed a computer to access the internet or a headset, while immigrants required a translator. By addressing these specific needs early on, they understood each demand to guarantee diversity in the sample of participants.

Another example of a project developed in Oslo to promote sustainable behavior was “The My Green Challenge.” The campaign engages Oslo’s residents to change their daily lives regarding various topics, from sustainable food and urban agriculture to recycling and waste reduction. However, the interviewee expressed concerns about the effectiveness of this strategy. While the campaign delivered

relevant information to the residents, the interviewee felt insufficient time to participate in the challenge and make significant changes to their daily habits.

A researcher with experience in gamification projects pointed out: “The fact that you put gamification does not mean that people will use it. People do not use it unless there is an incentive”. He added that getting the engagement takes much effort from the parties involved. Oslo Municipality is testing ways to give discounts to people who use more sustainable transport in a mobility app already widely used by the population.

As emphasized by all interviewees, effective communication is essential for participation and engagement. Due to the research, various projects have utilized data visualization and digital storytelling techniques. Oslo Municipality has created a user-friendly website that provides open data in an informative way, with an editorial context. This allows the general public to easily access raw data, download it, and gain insight into the information through a summary.

One of the interviewees pointed out that engaging citizens’ imaginations can be a challenge in participatory processes. “Most citizens think that when asked to provide their opinion, they need to be critical instead of dreaming what they actually want,” they explained. People often want to participate in criticizing but do not see the possibility of imagining improvements.

The question they raised was how to balance influence with responsibility. Sometimes, citizens want to influence a decision but do not take responsibility for the change, or they are held responsible but do not have a say in the decision-making process. For the interviewee, one solution is to think of citizen participation as a whole and not just as a specific event. It would require a long-term governance strategy that embeds citizen involvement and takes time to develop.

One notable trend that emerged from the interviews is the increasing use of SD projects to envision the future of cities. One professor interviewed provided an example of an exercise that prompted students to consider the future of their city by asking “What is” and “What if” questions. They recorded what they observed and imagined how it could be, visualizing future scenarios. According to the interviewee, the designer’s role is to transform an idea into a tangible artifact or experience.

The collaborative nature of design facilitated through co-creation workshops and the creation of visual or material artifacts supports collaborative meaning-

making and learning. Neuhoff, Simeone and Holst Laursen (2022) reveal three key features of design-driven futures: it fosters creative spaces for immersion, provides encounters for intra- and interpersonal reflections, and promotes mutual understanding through the visuality of design.

After conducting these nine interviews, we collected many examples of projects and research with different approaches regarding citizen participation and data usage. With the increase of urban digital data, there is a growing potential to collaborate with various stakeholders, including citizens, public sector entities, and private companies. The effective management of all available knowledge and data plays a significant role in shaping the city's future and has the potential to contribute to the generation of improved services for all.

4.2.3. Concluding remarks

The interviews show the potential for citizen participation in urban projects. Perhaps there are technological challenges, such as a lack of infrastructure, technical knowledge, and stakeholder engagement, but different approaches can be replicated in other contexts.

Although some projects use data visualization tools, they rarely apply them in workshops. Usually, they are digital products from research, such as websites for consultation and dissemination of information. While the volume of data has increased due to the online workshops, the data processing and analysis are still primarily manual and lack workflow automation.

It can be a time-consuming and resource-intensive process that may limit the projects. One possible solution to this challenge could be to explore using artificial intelligence and machine learning techniques to automate certain data processing and analysis aspects. It could help to streamline the process, reduce errors, and allow for more efficient use of resources. However, practical testing is still necessary.

The interviewees also reported social media as a source of information. Sometimes they use it to understand the target audience, but more often, as a tool to communicate with the population. Social media is rich in crowdsourcing data and could have extensive material for analysis. As it has unstructured data, some technical challenges must be overcome to take better advantage of it.

Design projects that predict the future of cities using SD processes are a trend observed in the interviews. Digital tools for online workshops offer new opportunities for immersive experiences. Now, it is possible to reach more people, quantify qualitative data, and realize asynchronous activities. The main issues identified were tested in a participatory process using mixed methods and digital technologies, which we will explain in the next sections.

4.3 Summary of first phase results

In this initial phase, we explored urban projects utilizing data and citizen participation. Through content analysis of Civitas project reports, we developed a WDA model detailed in Appendix B. Delving into interviews with industry professionals, we further examined the challenges and solutions identified.

Regarding big data, the abundance of available information necessitates mapping what is already accessible and collected—an initial step for broader information access. Interviews emphasized the value of data owners' involvement in co-design dynamics for interpreting this data. Public initiative projects sometimes have more straightforward data access.

Increasing citizen participation can leverage existing events, as observed in Civitas reports and interviews. Creating welcoming environments, perhaps through dinners or other incentives, is another effective strategy.

In the realm of institutional communication, a focus on transparency and the recognition of participation fatigue underscores the need to manage expectations continuously. The incorporation of plain language and a diverse array of both online and offline tools enhances communication channels. The interviews highlighted that acknowledging the diversity within society necessitates tailored approaches, understanding the motivation of each group, adjusting expectations, and making the value of participation prominently visible.

Crowdsourcing emerges as a source for generating ideas, opinions, and representative mixes while also serving as a promotional platform for various services. Social media, in particular, stands out as a rich reservoir of crowdsourced data, offering extensive material for analysis. However, the presence of unstructured data poses technical challenges that require careful consideration to maximize its utility.

Social media, characterized by its lack of access barriers and interactive nature, presents opportunities for sentiment analysis despite concerns about non-structured data and privacy, including the prevalence of fake profiles. While it serves as a rich source of information, its usage varies among interviewees, sometimes as a means to understand the target audience and more frequently as a tool for direct communication with the population.

Artificial Intelligence could be used in monitoring mobility patterns, extracting data from crowdsourcing platforms, and facilitating information translation. The exploration of AI aims to automate data processing and analysis, streamline processes, reduce errors, and optimize resource utilization.

Gamification strategies involve incentivization, user feedback, and statistical insights into travel habits. However, one example of a challenge is the limited timeframe for engaging users and inducing behavior modification. Successful implementation hinges on providing tangible incentives, such as discounts integrated into widely-used apps.

Data visualization, encompassing dashboards, easily understandable formats, and 3D city models, is an underutilized tool in the interviewees' workshops. Mapping visualization is typically reserved for analysis rather than the discovery process. A user-friendly website is an example of a resource to present open data informatively and enhances public access.

Co-design methodologies foster collaborative ideation, enabling the testing and evaluation of solutions. Methods such as questionnaires and journey diaries serve as tools for measuring impact and gathering citizen data. The Miro platform, with its capability to craft immersive narratives, guides participants through interactive boards, transforming the experience into virtual environments. Nevertheless, the incorporation of two in-person meetings, one at the beginning and one at the end, could be instrumental. These meetings would facilitate introductions, enhance engagement, and provide a meaningful closure, fostering a celebratory atmosphere that serves as an incentive for future participation.

Prototyping through pilot projects and demonstrations of sensor technologies provides a low-pressure environment for experimentation, allowing for the building of a stronger collective memory. The Future City Game is an example of employing data materialization. The interview emphasizes the designer's role in transforming abstract ideas into tangible experiences to envision future scenarios.

TOPICS	CIVITAS	INTERVIEWS
Big data	• Integrating transport planning • Changing in real-time based on the demand • Data collection and regular monitoring • Measuring impact • **Data auditing** • Real-time traffic data • Single platform integrating data systems. • Anonymized and aggregated formats	• Project to identify public data and encourage its use. The designer's role was to facilitate and translate the meeting to establish partnerships. • Responsible mediator to oversee data handling and facilitate translation. • **The public workers have easier access to collect data.**
Citizen engagement	• Flat the relations between citizens and public institutions • **Collaborating with other community initiatives** • Events in the neighborhood • **Confronting taboo topics.** • Online hackathons	• Holding dinners. • Creating an appealing environment. • **Taking advantage of neighborhood meetings and events already happening.**
Institutional Communication	• **Transparent communication** • **Continuous information** • **Plain language** • **Channels for distributing information** • **Avoid participation fatigue** • A combination of online and offline tools • Relationships with local anchors.	• Diverse and inclusive groups in society require different approaches and types of communication. • Understand the motivation of each group, adjust expectations, and make the value of participation visible.
Crowdsourcing	• **Tracking problems** • Suiting specific preferences • **Learning the communities and stakeholders' needs** • User-rated experiences • **Source of ideas and opinions** • Calling for ideas and opinions • **Representative mixes**	• **Social media is rich in crowdsourcing data and could have extensive material for analysis.** • **Unstructured data, some technical challenges must be overcome to take better advantage of it.**
Social media	• **Without access barriers** • **Interactive** • **Sentiment analysis** • **Non-structured data** • Privacy • Fake profiles.	• **Social media as a source of information.** • **Sometimes they use it to understand the target audience, but more often, as a tool to communicate with the population.**
AI	• Monitoring mobility patterns • **Retrieving data from crowdsourcing platforms** • **Translating information.**	• **Explore using AI to automate data processing and analysis aspects.** • **Streamline the process, reduce errors, and allow for more efficient use of resources.**
Gamification	• **Incentivizing users** • **Providing feedback and statistics about travel habits** • Influencing citizen behavior • **Raising citizen awareness on sustainable mobility** • **Comparative measures.**	• Limited time to engage in the challenge and modify habits. • "The fact that you put gamification does not mean that people will use it. People do not use it unless there is an incentive". • Give discounts to more sustainable transport in an app already used by the population.

Data visualization	• **Dashboards** • **Easily understandable formats** • 3D city model.	• **Visualizing data in workshops is uncommon;** visualization tools are typically used during analysis rather than in the discovery. • **User-friendly website offers open data in an informative way, with an editorial context.** This allows the public to easily access raw data, download it, and gain insight through a summary.
Co-design	• Citizen mobility labs • **Co-design workshops** • Implementing concepts, testing or evaluating the potential of solutions • **A questionnaire to measure impact** • **Journey diary** • TIPS and TOPS.	• Dataset owner in the workshop to clarify any doubts. • **Send data before the meeting to prepare the participants.** • **Miro tool for online meetings** • **Create immersive narratives to guide through the boards.** • Complementing online sessions with in-person meetings: one at the start for introductions and engagement, and one at the end for closure and celebration. • People often want to participate in criticizing but do not see the possibility of imagining
Prototyping	• Pilot projects • No pressure to succeed • Demo sensor • **Building a stronger collective memory.**	• **The Future City Game is a collaborative process that utilizes data materialization.** • Consider the city's future by asking "What is" and "What if", recording observations, and visualizing future scenarios. The designer's role is to transform an idea into a tangible artifact or experience.

Table 6 - Summary key outputs, with gray highlights indicating aspects for testing in the next phase.

Table 6 provides a summary of key findings from both studies, categorizing insights from Civitas projects and participant interviews. Noteworthy ideas, examples, difficulties, and quotes from interviewees shed light on the challenges these projects face. Highlighted in gray are aspects slated for testing in the next phase of the research. Due to time and scope constraints, we selected specific factors for further investigation, focusing on the feasibility of conducting diverse studies that test data collection and analysis methods, particularly in the realms of big data and citizen participation.

5.
Exploring the collection of urban mixed data[7]

After this initial exploratory phase, where we identified some solutions used in mobility projects, our subsequent goal was to test how to collect different urban data. The purpose of these studies was not to draw conclusive findings but rather to experiment with potential data collection processes, which would later be co-analyzed in the subsequent method. The question guiding our focus during this data collection phase was: what is the impact of weather on urban mobility in Rio de Janeiro? The primary objective of this chapter is the analyses of these studies centering around the process of data collection, shedding light on the challenges and smooth aspects of collecting mixed data. It's crucial to note that the subsequent chapter will co-analyze the data specific to urban mobility, offering a more comprehensive examination of the findings.

Initially, we gathered relevant open data available in the city for the proposal's objective. As seen in the case studies, there are numerous open data sets available on government portals, in addition to data generated by citizens through social networks. Leveraging these open sources to create collective intelligence for investigations in different areas is known as OSINT (Open Source Intelligence). OSINT involves the collection, processing, and correlation of publicly available information from open databases, such as mass media, social networks, forums, blogs, government public data, or commercial publications (Pastor-Galindo *et al.*, 2020).

In the Civitas projects and interviews, we observed that many data sets are open but not necessarily accessible to the general public. The city of Rio de Janeiro has a portal for open data dissemination, DataRio, but there are some usability issues. In the first section of this chapter, we present a usability study of the Rio de Janeiro open data portal. We will describe our experience in accessing the data in the required format.

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[7] This chapter was partially published under the following reference: CORDEIRO, R.; QUARESMA, M. Integrating mixed data for a human-centred mobility. In: , 2023, Berlin. Proceedings of the 8th Humanist Conference. Berlin: [s. n.], 2023. p. 139–144.

We recognized the importance of mixed methods for a comprehensive analysis of the experience. Additionally, we observed a solution in a Civitas project that employed a journey diary for qualitative mobility data collection. Therefore, in the second section, we introduce this technique, where we tested the use of social media for communication and information collection, gamification for engagement and data visualization.

According to Serna *et al.* (2017), technological development has provided an opportunity to enhance traditional research methods to collect information on travel behavior, reducing data bias, respondent burden, and improving data quality. For them, user-generated content is growing rapidly, and social networks have become a valuable source of knowledge.

Therefore, in the third data collection technique, we tested extracting Twitter[8] posts and analyzing the text sentiment through machine learning. The query words were based on the diary comments, combining the data for a broader result.

5.1. Open urban mobility data

The methodology employed in this study involved using open data from Rio de Janeiro to investigate the impact of weather on urban mobility. The initial data collection process relied on gathering information from the DataRio website. DataRio is a portal for disseminating information by the municipal government, fostering integration, and enhancing data production about Rio de Janeiro. Although it provided a valuable foundation for the analysis, we requested additional data from the respective companies responsible for the transportation services to ensure a comprehensive examination. The Brazilian information access law (nº 12.527/2011) obligated government-operated companies to provide transparent data, while the exact requirement did not bind private companies.

The research has focused on obtaining data on the daily number of bus, taxi, bicycle, tram, train, metro, and ferry trips in Rio de Janeiro, spanning as far back as the earliest available records up to the present day. We obtained monthly data from the municipal portal and more detailed daily information through requests directed

[8] To maintain consistency, ensure broad recognition, and enhance clarity, we opt to retain the name 'Twitter' in our text despite the platform's recent name change to X during our research.

at operators. In contrast, weather data was relatively more accessible, as detailed information was readily available on the AlertaRio[9] website, the municipal alert system for heavy rains and landslides on slopes. This data collection and integration method is a crucial foundation for this study's subsequent analysis and findings.

5.1.1. Data Rio contextual inquiry

In the initial phase of data collection from the DataRio portal, we encountered usability challenges, hindering efficient access to the data. To investigate whether this issue was isolated, we conducted a contextual inquiry on March 27, 2023, involving 15 participants—undergraduate design students attending a data visualization class. Participants signed a consent form (Appendix E), their average age was 23 years old, and they had no prior experience with databases. They were given the task of selecting a public CSV database for a subsequent data visualization exercise in Processing. We aimed to evaluate their experience navigating the DataRio site and assess the challenges faced in utilizing the available urban data.

Utilizing contextual inquiry, a method blending user interviews and ethnography, we observed and questioned participants while they worked in their environment (Marsh, 2018). As they searched for data, we posed broader questions about their overall opinion of the website (see the base script in Appendix F). Figure 10 shows various pathways the users could follow.

We inquired about their specific objectives, exploring whether they entered the website with a predefined goal or navigated freely before selecting data (Figure 11). Our focus was on understanding their search strategies, mental pathways, and any challenges they faced, to gain insights into their search behavior, information transparency, and mental models.

[9] http://alertario.rio.rj.gov.br/download/dados-meteorologicos/

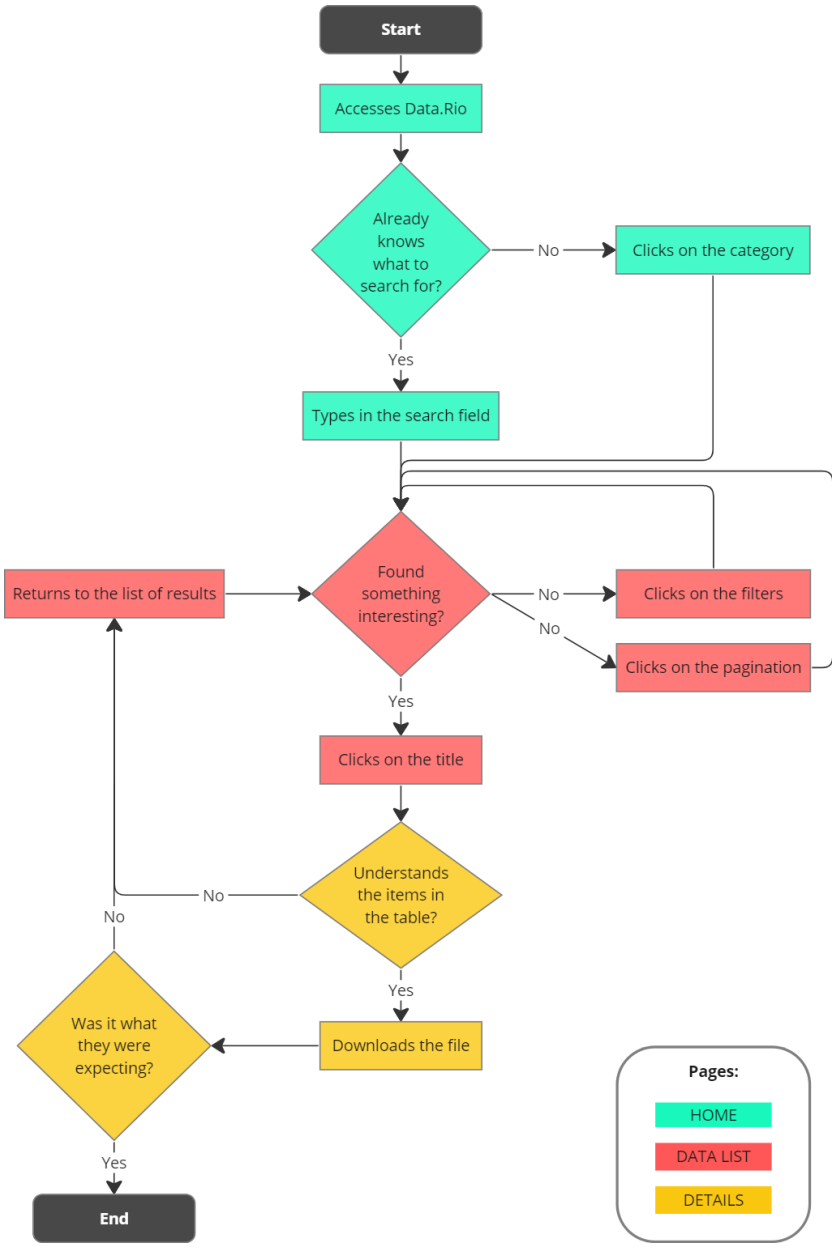


Figure 10 – Contextual interview navigation flow

After participants selected a dataset they were interested in, we asked them if they could understand the content of each table, including the data format. These questions were designed to assess how well the site aligned with real-world understanding, how clear it was for non-specialists, and how user-friendly the interactions were. We also asked about their ability to download and use the selected dataset.

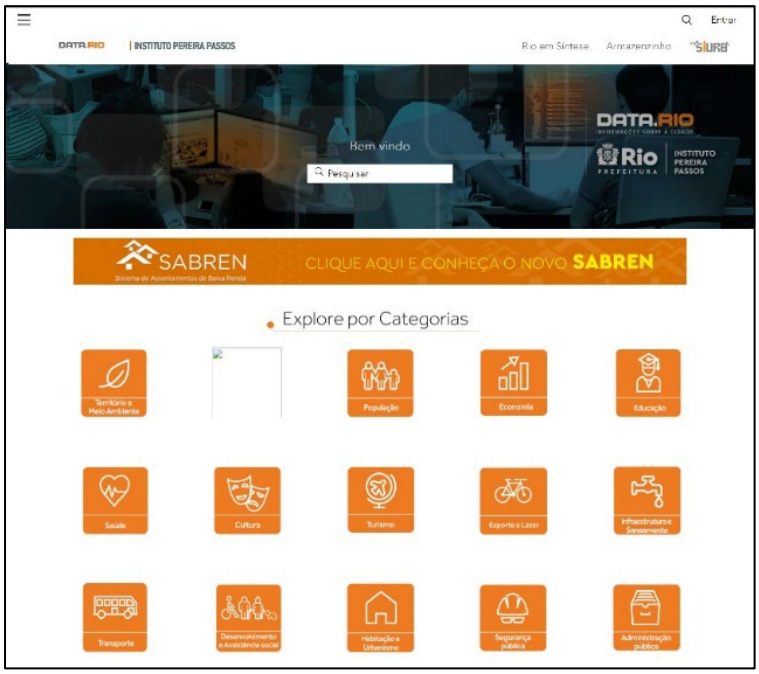


Figure 11 – DataRio's homepage featuring categories in orange squares and a centralized search field at the top of the banner

Following the navigation session, we administered a post-test questionnaire—the System Usability Scale (SUS), a widely used tool for assessing perceived system usability (Appendix G). The SUS consists of 10 statements, and participants rate their agreement on a five-point scale. The overall score, ranging from 0 to 100, provides an indication of perceived usability (Tullis and Albert, 2013).

5.1.1.1. Interviews: results and discussion

The research findings cover a range of user experiences and difficulties faced while using the data exploration platform. To evaluate these challenges, we compared them against Nielsen's Heuristics (Nielsen and Mack, 1994), which is a set of 10 usability principles for user interface design:

1. Visibility of System Status;
2. Match between system and the real world;
3. User control and freedom;
4. Consistency and standards;
5. Error prevention;
6. Recognition rather than recall;

7. Flexibility and efficiency of use;
8. Aesthetic and minimalist design;
9. Help users recognize, diagnose, and recover from errors;
10. Help and documentation.

Initially, users commonly exhibited the behavior of searching for data without a specific objective, expressing difficulties in comprehending the contents of each table. This confusion persisted, prompting questions about the necessity of downloading files for viewing.

Participants had the option to initiate their search either by entering keywords in the search field or by choosing a category directly from the website's homepage. Some participants noticed discrepancies where certain categories were shown on the homepage but were missing from the filters, revealing an **inconsistency** on the site, contradicting heuristic 4.

The categories and filters were common points of complaint (Figure 12). When users applied filters, they found that there were only a limited number of results. One participant expressed their frustration, saying, "There are categories that have no data; it's frustrating, creates an expectation, and there's nothing". Additionally, some users were confused about the differences between filters and tabs.

Users have reported issues with the filtering system, which has resulted in unintentional exits from categories and inconsistencies in the outcomes. The problem lies in the fact that users are getting different results depending on the category they select, which is confusing. For example, when a user selects a category on the homepage, they get a certain number of responses, but when they apply the same category filter on the results page, they get a different set of responses.

A participant initially sought transportation data but, when attempting to filter by file type (CSV), exited the transportation category, even without clearing that category. This lack of **control and freedom** hindered the user's ability to navigate effectively.

Participants in a study were tasked with locating CSV files. Instead of using the filter, they had to read the file type mentioned below the title and look for CSV. There were instances where the filter only displayed one dataset. One participant shared their strategy: "I had to convert Excel data to CSV to work with it". The

cognitive load of reading each label could have been avoided if the filter functioned properly, aligning with the principle of **recognition rather than recall**.

Users faced challenges in understanding the data timeline due to the absence of date and category filters. The lack of a date filter impacted the **system status visibility**, as the updated date sometimes differed from the year in the title. Users expressed concerns about this issue, making it difficult to grasp temporal aspects. Finding recently updated data proved to be a reported challenge, contributing to confusion.

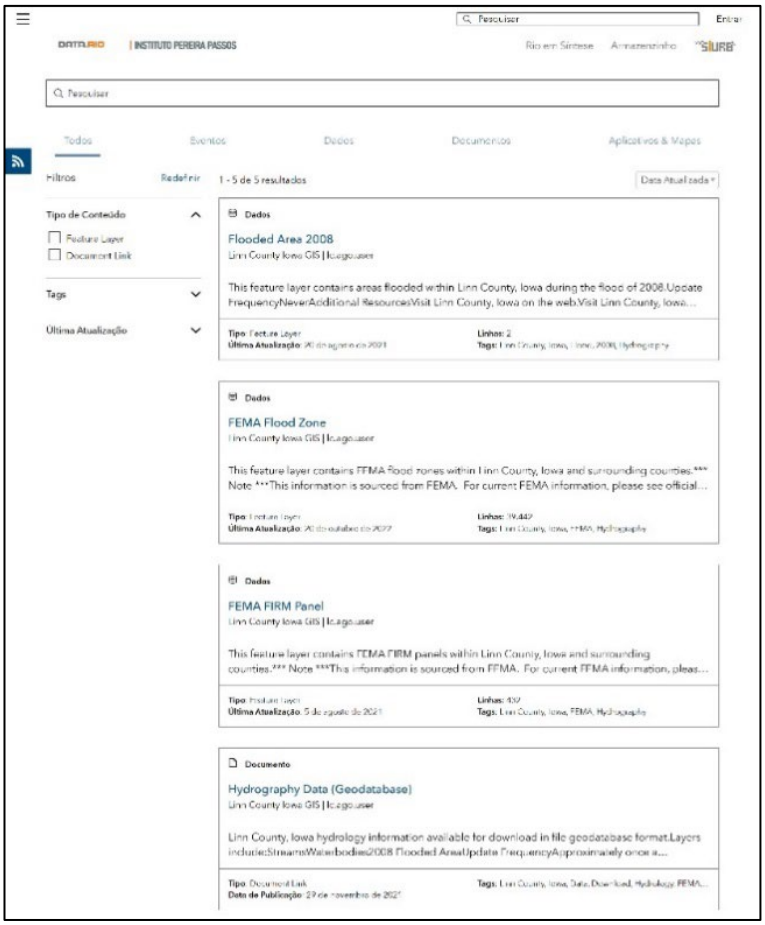


Figure 12 – List of available database results with filters on the left

A participant was looking for a table with a specific theme but could not find it. As a result, they changed their mind. They tried searching for the table category but were unable to locate it. They then searched using the search field but were not sure if the information was not available or if they did not know the correct terminology. They felt it was important to have a **match between the system and the real world**, with terms that are simple and easy to understand. They complained, "I can find more information on Google Scholar than here."

During interviewing, it was found that users were having a hard time understanding the information presented in the tables, leading to confusion. Many participants were unsure whether they needed to download the files to view them or not. One participant even asked during the interview, "Do I need to download the file to see it?" To improve the user experience, the system should be designed in a way that helps users **recognize errors, diagnose them, and recover** from them without having to download each file to verify its content.

While attempting to download data, participants encountered various obstacles. One concern expressed was the lack of consistency, as some data was found on entirely different websites. One participant summed up the irritation by saying, "When you enter, you think it's one thing, and it's something completely different." This example highlights a recommendation from Nielsen's heuristic for **Consistency and Standards**.

A participant in the study found herself frustrated when she couldn't access the information she liked. She was particularly interested in a visualization that showed a timeline on a map, but she was unsure how to access the data from that visualization due to the format. Despite her interest, she eventually gave up and looked for another set. Having **help and documentation** could have made this situation much easier for her.

One issue that has been reported is regarding the way information is presented on the page that contains table details (Figure 13). According to one of the participants, there is a high amount of information on the page, which makes it difficult to understand. In one instance, the suggestion text appeared to be a part of the table. Since there was no introductory text, the related datasets appeared just below the title, giving the impression that everything belonged to the same database. To make the information more accessible, it is recommended to adopt an **aesthetic and minimalist design**.

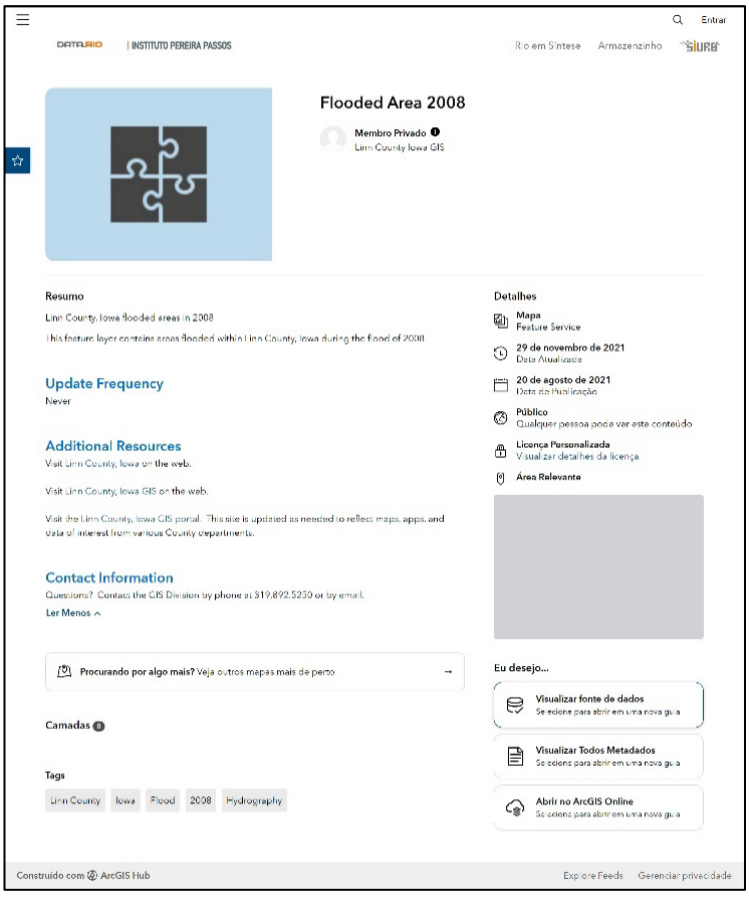


Figure 13 – Page displaying database details

Users discovered inconsistencies in some data, with one participant reporting, "I found data indicating that the Planetarium was located in the neighborhood of Santa Teresa". While some users expressed satisfaction with the site, others found the search process frustrating. Overall, users acknowledged the site's concept but suggested areas for improvement.

5.1.1.2. SUS results

From the responses to the SUS questionnaire, we could calculate the usability score of DataRio. According to Tullis and Albert (2013), the SUS score is computed by summing the score contributions for each item. Each item's score ranges from 0 to 4. For items 1, 3, 5, 7, and 9, subtract 1 from the scale position. For items 2, 4, 6, 8, and 10, subtract the scale position from 5. Multiply the sum by 2.5 to get the overall SUS score.

After analyzing the questionnaire responses using the SUS method, we obtained a final SUS score of 43.75, a value below the threshold considered

acceptable. In interpreting SUS scores based on their data, scores below 50 are deemed not acceptable, scores between 50 and 70 are considered marginal, and scores above 70 are deemed acceptable. This indicates that users expressed significant usability concerns with the DataRio platform, highlighting areas that may require improvement for a more satisfactory user experience.

At the end of the questionnaire, we posed an open-ended question regarding user recommendations. A predominant theme in participants' suggestions focused on enhancing the platform's usability. Users underscored the importance of incorporating a date filter to streamline the retrieval of recent data. One participant succinctly expressed: "Implement date filter; enhance search system; expand data formats," encapsulating the diverse nature of proposed enhancements.

Another participant suggested exploring other database websites as benchmarks for usability analysis. They envisioned the implementation of a search system centered around user needs, emphasizing the significance of customized searches to enhance the overall user experience.

Concerns about the lack of integration among data sets prompted calls for a comprehensive site overhaul, with one user asserting: " The data is not integrated. For example, if you want to know which subgroups compose the groups, we don't know because the data is closed". This feedback emphasized the importance of enhancing data integration to provide a more cohesive and interconnected user experience on the platform.

Users expressed a substantial interest in improving visual data representation, as most data lacks a quick visualization. Additionally, there is a pressing need to enhance the functionality of category-based searches. There is a clear call to incorporate data organization by year to streamline access to the latest insights. These users' feedback underscores the importance of refining both the visual and functional aspects of the platform to meet their expectations for a more effective and user-friendly experience.

5.1.2. Transparency

Our goal was to gather data on the number of trips for different modes of transportation per day during the summer, from December 21, 2022, to March 21, 2023. On the DataRio website, the data were more extensive, providing an average

number of trips instead of daily figures, which didn't suit our needs as we wanted to cross-reference them with daily meteorological data.

We initiated data requests on the transparency portals of municipal and state agencies. We submitted a request for each mode of transportation, and the transparency portal directed each request to the respective department. Taxi, bus, and tram data were requested through the Rio de Janeiro City Hall's 1746 portal[10]. Metro, ferries, and trains were requested through e-SIC[11], the Electronic Citizen Information Service of the State of Rio de Janeiro. As bicycles, Bike Rio, and Uber are private companies, they are not subject to federal transparency laws, so we requested the data directly from the responsible department of each company.

The City Hall's portal provided a table with taxi data exactly as requested. The data related to bus transportation were displayed in a PowerBI dashboard that contained public information. At first, the dashboard lacked daily breakdowns. However, upon our request, they updated the dashboard to include this information. Although there was no provision to download the data in CSV format, the information was accessible and open to the public, allowing us to copy it. The Engineering and Architecture Directorate of the Carioca Company for Partnerships and Investments stated that they possessed tram data and offered to provide the requested information through scheduled contact via telephone or email. However, attempts to contact them were unsuccessful.

For the requests made to the state government, they provided the metro, ferry, and train data in the requested format. We only had access to the daily passenger data of the metro after the pandemic, due to the implementation of daily passenger registration requirements for better control over public transportation. Initially, we were uncertain if we needed a broader comparison, so we directly contacted Metro Rio's customer service through the company's institutional website to request the older data. We scheduled a conversation to inform them about our research, and the data were provided in the requested format.

The shared bikes in Rio de Janeiro belong to TemBici. We reached out to the urban planning department of the company via email to request travel data from their systems. They replied with a data usage agreement to fill out and sign. This

[10] https://www.1746.rio/hc/pt-br/articles/9567624997403
[11] http://www.esicrj.rj.gov.br/

open data includes monthly information on each trip taken within the system, giving us the ability to calculate the daily number of trips.

On April 11, 2023, we began the process of requesting information. The State of Rio de Janeiro provided the quickest response on May 5, which was approximately a month later as shown in Table 7. The slowest response was from TemBici on June 21, as it was more challenging to find the contact for the responsible department. Despite the slow process, most of the requested data were efficiently provided in an accessible format not available on the DataRio website.

TRANSPORTATION MODE	RESPONSIBLE COMPANY	CONTACT	RECEIVED DATE	FORMAT
Bicycle	TemBici	Direct Email	21/06/2023	CSV
Bus	Rio Ônibus	Portal 1746	31/05/2023	Dashboard
Metro	Metrô Rio	Website Contact	17/05/2023	CSV
Ferries	CCR	State Citizen Information Service	05/05/2023	CSV
Train	Super Via	State Citizen Information Service	05/05/2023	CSV
Tram	Companhia Carioca de Parcerias e Investimentos - CCPar	Portal 1746	-	-
Taxi	Táxi Rio	Portal 1746	08/05/2023	CSV
Uber	Uber	Website Contact	-	-

Table 7 – Information about the availability of open data on various transportation modes

With this data in a daily and CSV format, we could clean and integrate them with meteorological data. In Chart 1, we have the daily data for all modes of transportation we requested during the summer of 2022-2023. They have different magnitudes, so direct comparisons are not possible, but we can observe behavior patterns. Some days experienced drops or peaks in usage, which can be further investigated to understand the reasons.

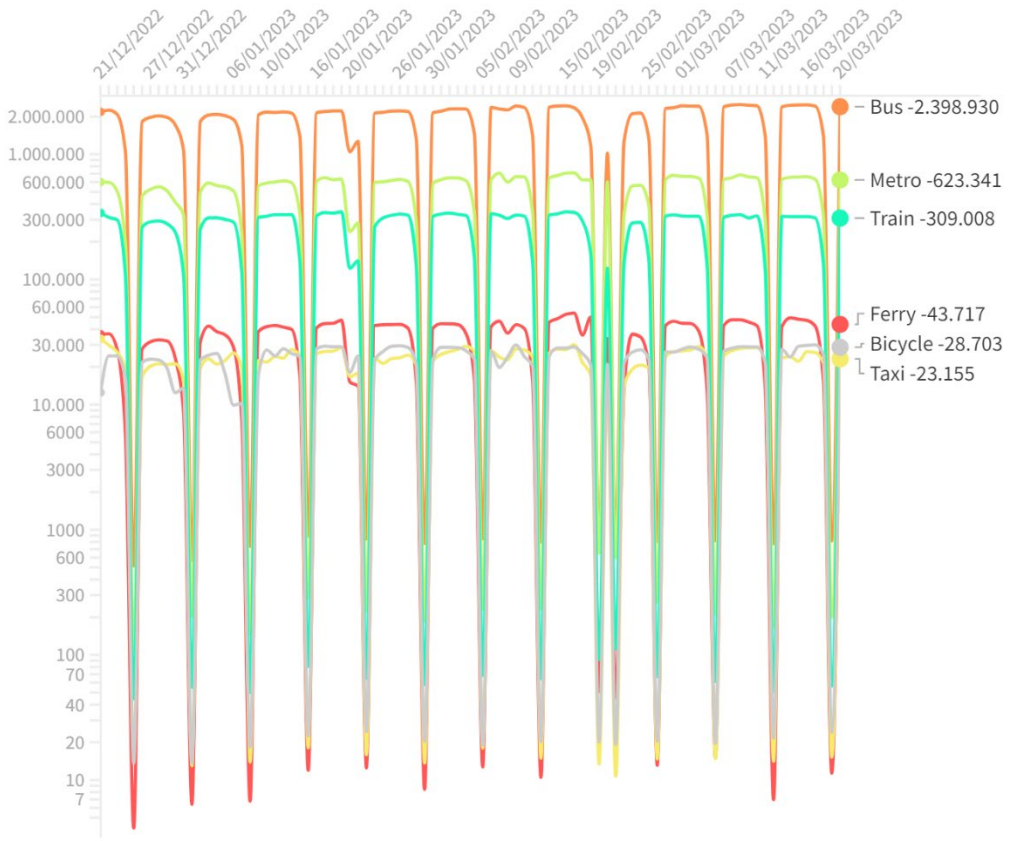


Chart 1 – Graph illustrating the daily count of journeys throughout the summer season, capturing the fluctuation in travel patterns and trends over the specified period [12]

5.1.3. Analysis and discussion

The analysis of available data sets revealed several significant findings. Firstly, many open data sets were unstructured, requiring integration efforts for meaningful analysis. We also encountered difficulties locating contact information on the data owner's website, hindering data acquisition and communication. Moreover, the data sets exhibited different structures, with some tables divided time by hour, day, or month, as well as location per station, neighborhood, or city, making the cleaning and standardization process challenging. Furthermore, the datasets lacked informative descriptions and valuable metadata, making it necessary to download each table to understand its subject matter. One notable finding was the effective functioning of the government's channel for transparency within the information access law. This channel successfully provided the requested

[12] https://public.flourish.studio/story/2075548/

tables in the exact format as specified, demonstrating compliance with regulations.

As shown in the contextual interviews, Rio's public open data website has many usability issues, making it difficult to access and understand it. The user challenges and recommendations unearthed in this study illuminate the intricacies of user interactions with data exploration platforms. The qualitative insights provide a roadmap for iterative enhancements, emphasizing the importance of user-centric design, improved search functionalities, and increased transparency in data representation. As the platform evolves, addressing these user-driven insights can pave the way for a more accessible, intuitive, and satisfying data exploration experience.

According to Simeone, Morelli and Götzen, De (2021), there is an imbalance between the supply and demand sides of open data. Policies have predominantly concentrated on quantitatively establishing data repositories, overlooking the emphasis on re-use. The long-term demand side lacks proper stimulation due to the absence of a consistent framework for orchestrating strategic interventions in shaping an open data ecosystem. Additionally, there is no consolidated practice or community sharing knowledge and experiences in working with open data. For them, these practices are mostly within the grasp of individuals and organizations with specific data literacy and data science competencies, constraining the democratization of open data production and usage.

For Concilio, Molinari and Morelli (2017), the urban dimension is crucial for both utilizing and producing data, turning cities into open-air data factories. However, they warn that citizens face significant restrictions in accessing and using these datasets for their purposes, despite being contributors or owners of the data. While technical literacy poses a skill barrier, there is also a lack of awareness among citizens regarding the potential of this resource. Additionally, certain datasets remain undisclosed, limiting the possibility of becoming open and accessible to all.

During our study, we encountered this type of challenge that required the acquisition of specific skills, each serving distinct purposes. We needed to delve into Python for data scripting and manipulation, utilize the software Tableau, Processing, and Flourish for visual analytics, comprehend JSON format for effective data handling, and master data processing techniques to ensure a comprehensive understanding of the information at hand.

Thus, after collecting transportation data, we integrated it with meteorological

data available on the Alerta Rio website in Rio de Janeiro (Chart 2). We then calculated the maximum temperature recorded each day across all sensors in the city and correlated it with the number of trips taken for each mode of transportation. This helped us gain a better understanding of the relationship between weather conditions and transportation usage in the city.

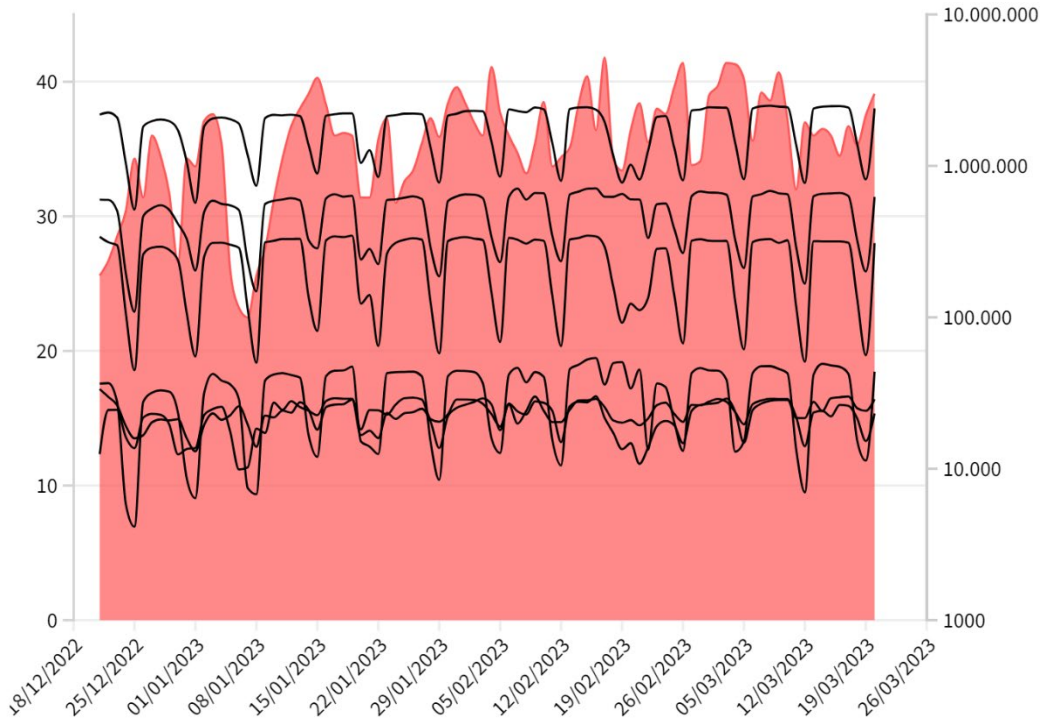


Chart 2 – Graph depicting temperature and travel frequency, highlighting specific days with maximum temperatures exceeding 40°C

Our goal was to explore whether mobility behavior changes with temperature variations. However, we cannot solely cross these two variables and believe there is a causal relationship. Dykes (2020) cautions against falling into the correlation fallacy, which occurs when individuals mistakenly perceive coinciding events as indicative of a cause-and-effect relationship. Variables are considered correlated if they exhibit similar or inverse fluctuations. Nevertheless, it is essential to bear in mind that merely observing a related trend between two variables does not imply a direct causal relationship between them.

Therefore, it is important to explore other forms of data collection to comprehensively analyze mixed data. Data integration can occur in different ways: a database could be used to validate or help explain another database, explore

different types of questions, or guide better instruments when they are not well-defined for a sample. According to Creswell and Creswell (2018), the approach can enhance an experiment, such as collecting qualitative data to help explain quantitative results. It can also be used in case studies or at different stages of research. The collection methods can be:

- **Convergent:** In this approach, the research converges or blends quantitative and qualitative data to generate a broad analysis of the problem. The researcher collects both types of data simultaneously and then interprets the results, explaining contradictions or incongruities.
- **Sequential Explanatory:** In this method, the researcher first conducts quantitative research and then analyzes the results to provide more detailed explanations with qualitative research. It is considered explanatory because the initial quantitative data is explained by qualitative data. It is considered sequential because the initial quantitative phase is followed by the qualitative phase.
- **Sequential Exploratory:** This method is the opposite of the sequential explanatory method, as the researcher begins with the qualitative research phase, understands the participants' perspectives, analyzes the data, and uses the information to create the second quantitative phase. The challenge is to focus on the findings of qualitative research and define the sample selection for both phases.

In the upcoming section, we delve into qualitative research, employing a convergent approach. This methodology involves the simultaneous collection of both quantitative and qualitative data, aiming to acquire a comprehensive and nuanced understanding of the identified problem.

5.2. Urban diary study

We conducted a user diary study with citizens reporting their experiences as they traversed the city. This approach captured real-time observations and subjective perspectives on how weather impacts daily mobility choices. Our approach involved testing the method through a post-application questionnaire. By scrutinizing the method's performance, we gained insights into its strengths and

limitations, enhancing our understanding of its applicability and potential improvements. Simultaneously, the analysis of mobility provided data on how individuals navigate and respond to weather-related challenges in their routines.

5.2.1. Methodology

The research employed a diary study conducted in March 2023 in Rio de Janeiro, where participants recorded their observations and data at specific moments, documenting various aspects related to their experiences (Marsh, 2018). Initially, a pilot test was conducted with eight participants to refine the methodology. Subsequently, 30 participants were recruited, with 19 actively engaging in the diary study.

The diary study is a qualitative technique, so the sample size should not be large. Marsh (2018) recommends between four and six participants per user group, but it is advisable to recruit more people. There is typically a dropout rate of 15% to 20% since diaries last longer than other types of research and require more involvement.

During recruitment, we queried about their travel frequency using different transportation modes, to recruit a minimum of six participants who used at least once a week each mode of transportation (Appendix H). To ensure a diverse participant sample, we initially targeted residents of neighborhoods with access to various transportation modes, such as ferry terminals, bike lanes, and metro stations. Once recruited, participants were encouraged to share the study with friends in similar regions, employing a snowball sampling technique that facilitated gathering a representative number of participants for each mode (Lazar, Feng and Hochheiser, 2017).

Instagram was chosen as the platform for data collection and participant communication due to its widespread usage and user familiarity. Instagram is the most consumed social media platform in Brazil, accounting for 14.44 monthly hours, according to Comscore (2023).

We created a business account on Instagram named "Citizen Experience" (Figure 14) and invited recruited participants to follow it. Participants signed a consent form (Appendix I), approved by the PUC-Rio ethics committee (Appendix A), authorizing access and use of information shared on the social media platform.

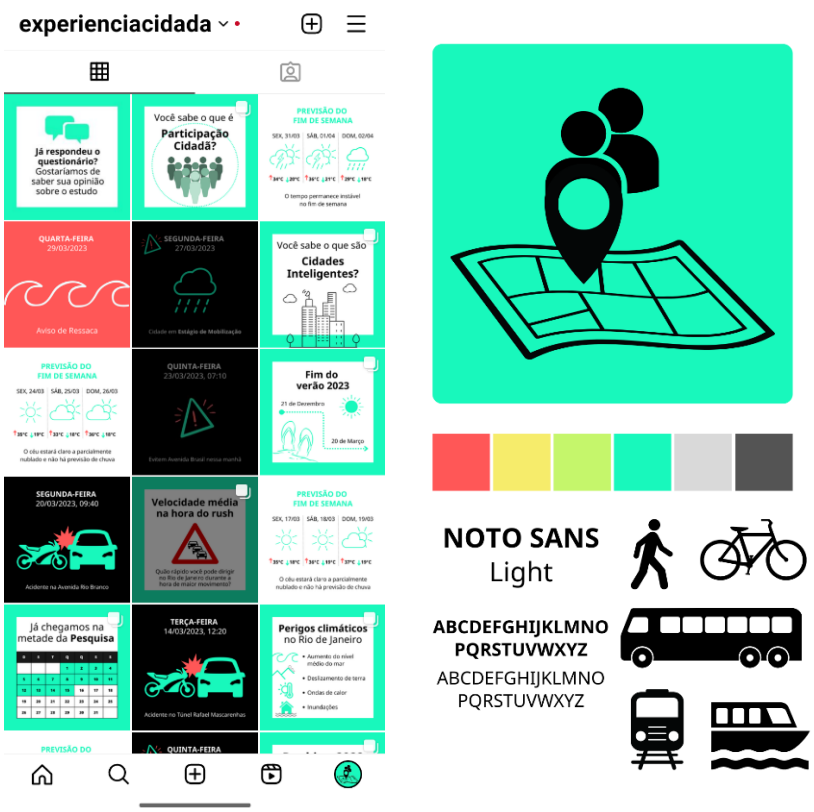


Figure 14 – Instagram Citizen Experience used for diary study data collection.

The diary component of the study was shared daily through stories (Figure 15), allowing participants to comment on their experiences, and providing details such as the day, hour, departure, and arrival neighborhoods. This information facilitated the determination of travel times, factors influencing transportation choices, and insights into the purpose of travel, mode of transportation, weather conditions, thermal sensation, and satisfaction levels. Close-ended questions were posed, with opportunities for participants to add open-ended responses.

These stories were consistently posted every day at 6 AM, with an additional evening reminder for those who may have forgotten to respond. Participants could respond multiple times based on the number of trips made, indicating the day and time of each entry. We adjusted the format after the pilot test, as initially each story corresponded to a specific day. We observed that participants were not necessarily registering their trips in real-time and could respond with delays. Therefore, specifying the period allowed them to respond at any time.

After the pilot test, common participant queries were addressed through a tutorial highlighted in the study profile. Participants responded through direct messages, facilitating communication for any inquiries. We requested additional

information to delve into specific behaviors, such as when a participant, who usually commuted by bicycle, chose to drive one day without specifying the reason. In such cases, at the end of the day, we inquired to clarify the atypical situation.

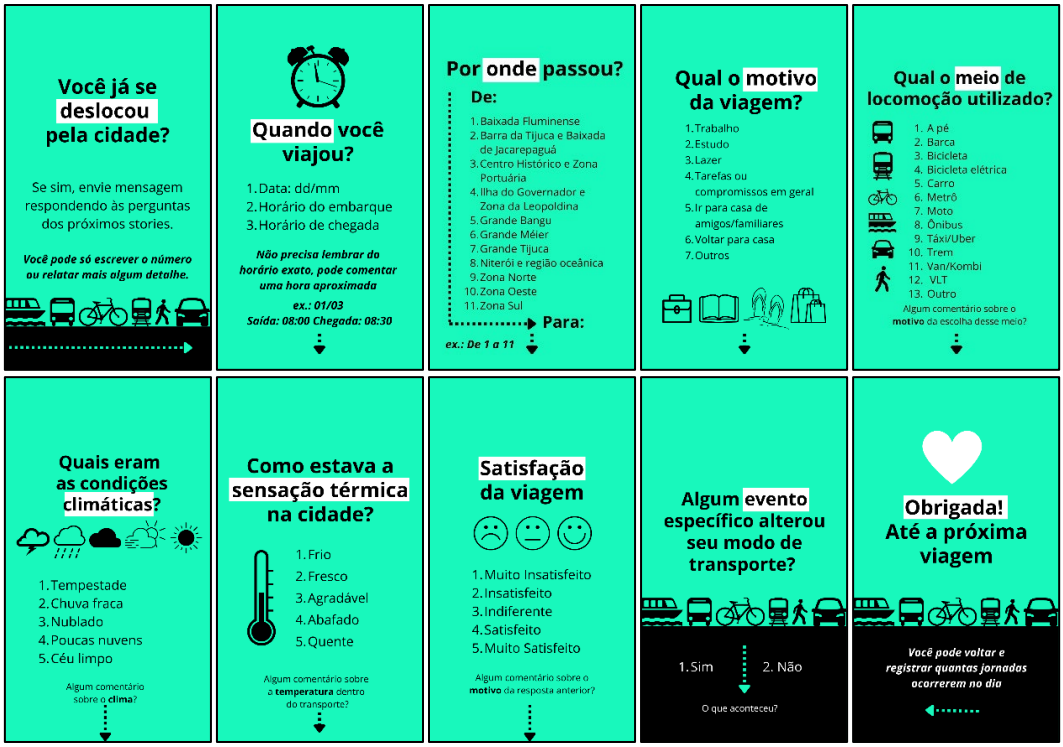


Figure 15 – Daily stories shared with the diary.

Posts were shared to inform participants about curiosities, weather conditions, and traffic, making the account not just a data collection tool but also a source of content. Weather and traffic information were redesigned using the project's identity, based on official data shared by the government (Figure 16).

Figure 16 – Weather-related posts: the first indicates the city's response to heavy rainfall, the second shares the weekend forecast every Friday, and the last one warns about beach surges.

Since the diary has a longer duration, it is important to employ engagement techniques. As seen in the results of the previous chapter, one feature that enhances citizen engagement is gamification. Therefore, we incorporated playful elements to encourage the completion of the diary with information about traffic and travel statistics, showcasing the progress during the "challenge", position in relation to other participants, trophies, and rewards.

Every Friday, we shared a quiz in the stories using Instagram's multiple-choice question feature, challenging participants to reflect on topics related to sustainable mobility using research data (Figure 17). In the following week, we posted the quiz responses through several images explaining the topic. Additionally, simplified information about climate change, urban mobility, and participation was shared to increase interest in the research topic and encourage participation (Figure 18).

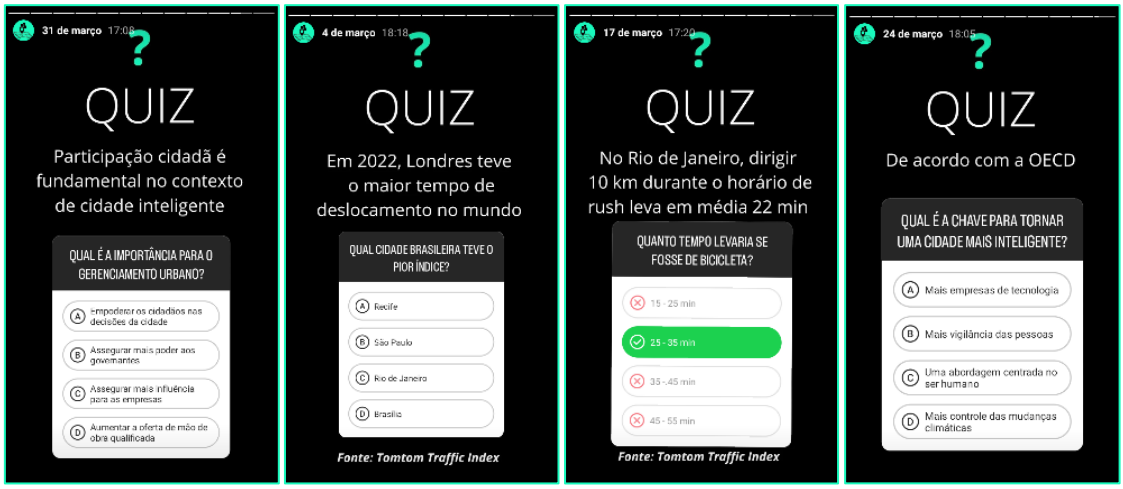


Figure 17 – Friday's weekly quiz with questions on citizen participation, the Brazilian city with the highest congestion index, bike vs. car travel time, and the definition of a smart city.

Content was generated using ChatGPT[13], an artificial intelligence (AI) tool, to suggest ideas for making complex information more accessible. For instance, based on the theme intended for the week, we sent data related to that theme, and the AI tool generated ideas of questions with four alternatives.

[13] https://chat.openai.com/

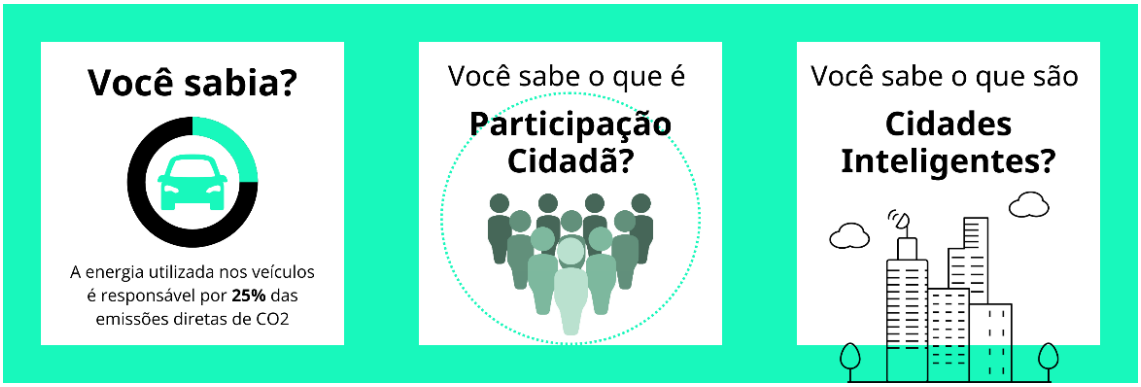


Figure 18 – Informative posts on study themes: vehicle CO2 emissions percentage, citizen participation explanation, and smart cities.

We shared a weekly ranking showcasing the most actively involved participants to motivate sustained engagement (Figure 19). The scoring system incorporated various factors, including the frequency of diary entries, comprehensive explanations in open-ended responses, engagement metrics such as likes and comments on posts, content sharing, participation in quizzes, and correct responses.

Figure 19 – Weekly ranking highlighting participants with the highest engagement, shared every Sunday. (name and photo modified for non-identification)

After one month, the most engaged participant received a personalized data visualization art piece as a token of appreciation, inspired by projects such as "*Data Selfie*" (Amorim, 2018), "*Data Portrait*" (Donath *et al.*, 2010) and "*Data Humanism*" (Lupi, 2017). The artwork depicted all registered trips, separated by the time of day, with icons representing the mode of transportation, colors indicating thermal sensation, position in the circle reflecting satisfaction, and the size of the radius representing travel time (Figure 20).

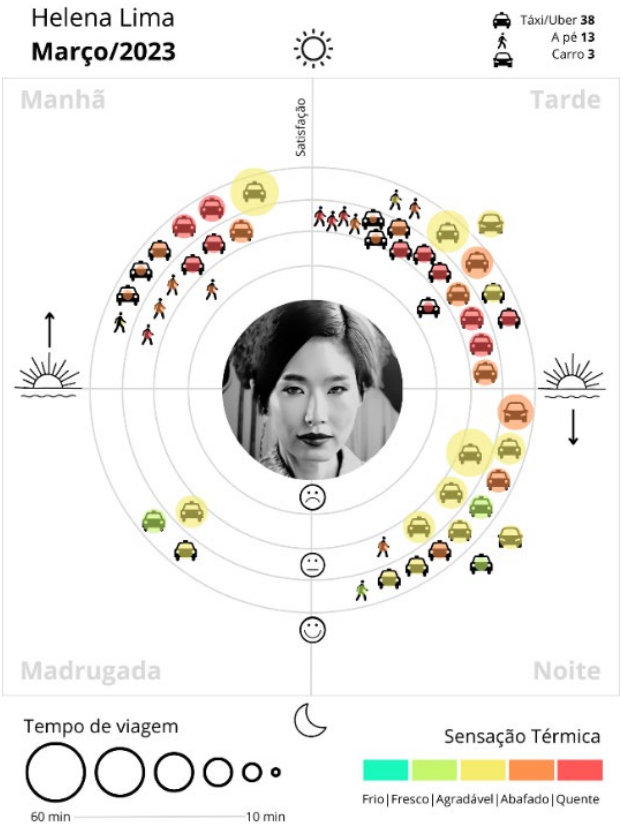
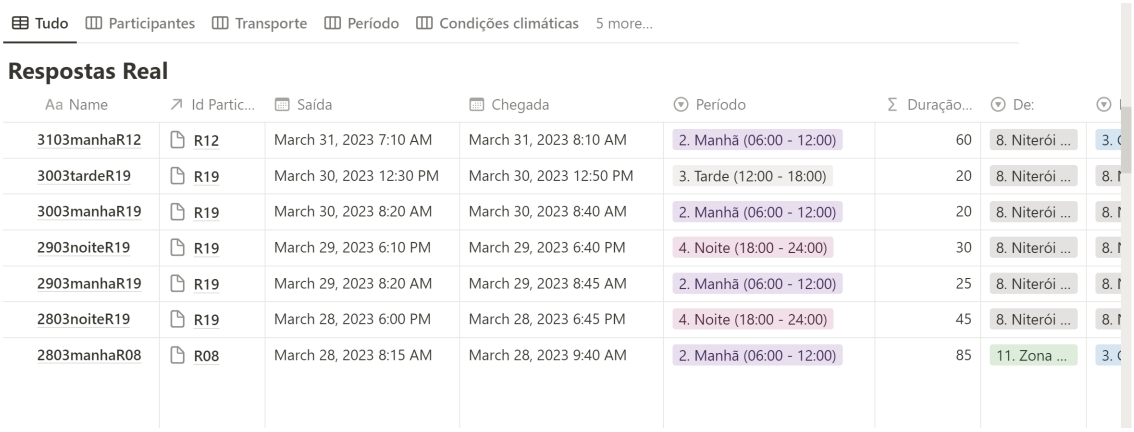


Figure 20 – Personalized data visualization with trips (name and photo modified for non-identification)

Responses were received through Instagram's messaging tool and were copied to a table in the Notion software (Figure 21). This database was integrated with participant and scheduled post information, enabling automatic engagement calculations, and facilitating subsequent analysis.


Tudo | Participantes | Transporte | Período | Condições climáticas | 5 more...

Respostas Real

Aa Name	Id Partic...	Saída	Chegada	Período	Duração...	De:
3103manhaR12	R12	March 31, 2023 7:10 AM	March 31, 2023 8:10 AM	2. Manhã (06:00 - 12:00)	60	8. Niterói ...
3003tardeR19	R19	March 30, 2023 12:30 PM	March 30, 2023 12:50 PM	3. Tarde (12:00 - 18:00)	20	8. Niterói ...
3003manhaR19	R19	March 30, 2023 8:20 AM	March 30, 2023 8:40 AM	2. Manhã (06:00 - 12:00)	20	8. Niterói ...
2903noiteR19	R19	March 29, 2023 6:10 PM	March 29, 2023 6:40 PM	4. Noite (18:00 - 24:00)	30	8. Niterói ...
2903manhaR19	R19	March 29, 2023 8:20 AM	March 29, 2023 8:45 AM	2. Manhã (06:00 - 12:00)	25	8. Niterói ...
2803noiteR19	R19	March 28, 2023 6:00 PM	March 28, 2023 6:45 PM	4. Noite (18:00 - 24:00)	45	8. Niterói ...
2803manhaR08	R08	March 28, 2023 8:15 AM	March 28, 2023 9:40 AM	2. Manhã (06:00 - 12:00)	85	11. Zona ...

Figure 21 – Notion software where all responses were compiled.

After participating in the diary for one month, we asked the participants to complete a survey about their experience during the study (Appendix J). The goal was to understand if the tested techniques were effective in increasing engagement in the research. The questionnaire, sent to all 30 initially recruited participants, including those who did not participate in the diary, was an online form, taking 5 to 10 minutes to complete.

5.2.2. Results and analysis

This diary study provided qualitative and detailed insights into participants' daily travel experiences and their interactions with various transportation modes, considering weather conditions and other contextual factors. Data visualizations were created offering a holistic insight into each participant's travel record, systematically organized by the mode of transportation, satisfaction levels, thermal sensations, and comments (Chart 3). The findings derived from this methodological approach contribute to a deeper understanding of the impact of weather on urban mobility in Rio de Janeiro.

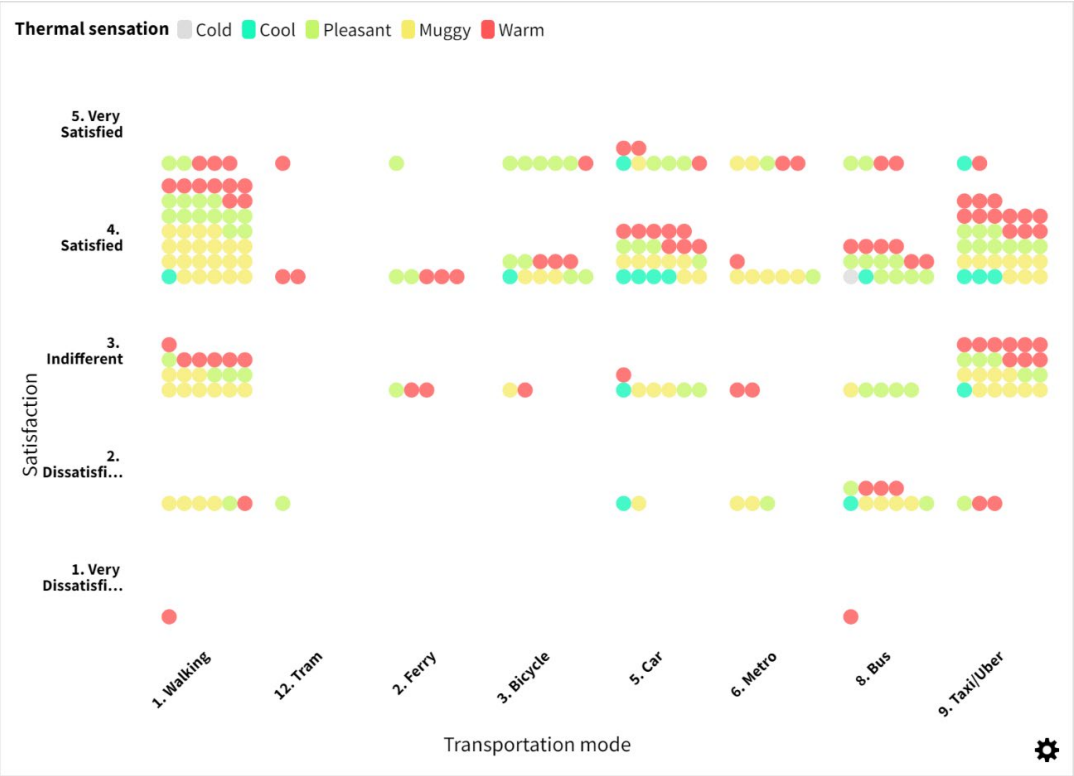


Chart 3 – All journeys recorded in the diary study[14].

Out of the 30 people initially recruited, only 20 responded. We first inquired about their Instagram usage frequency to determine if it influenced engagement (Chart 4). Subsequently, we asked if they responded to the diary (Chart 5). This was a filtering question; those who did not respond were directed to a question about the reasons for not participating. Among those who responded, we explored their motivations and their overall experience with the diary.

[14] https://public.flourish.studio/story/2075555/

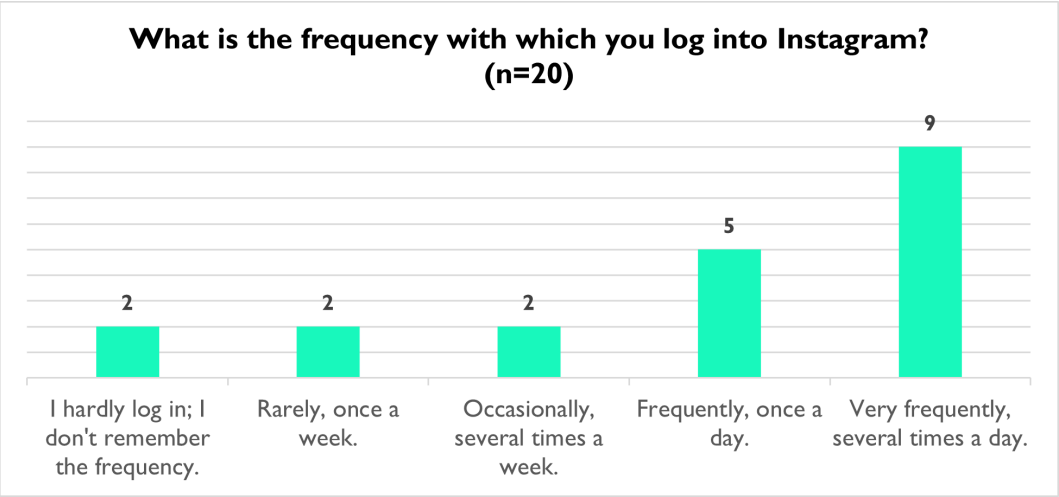


Chart 4 – Frequency using Instagram

Four individuals did not respond to the diary, and two made few entries. These six were directed to the question about the reasons for not participating. Among them, four stated that they frequently use Instagram multiple times a day, suggesting that Instagram itself was not the primary reason for non-participation.

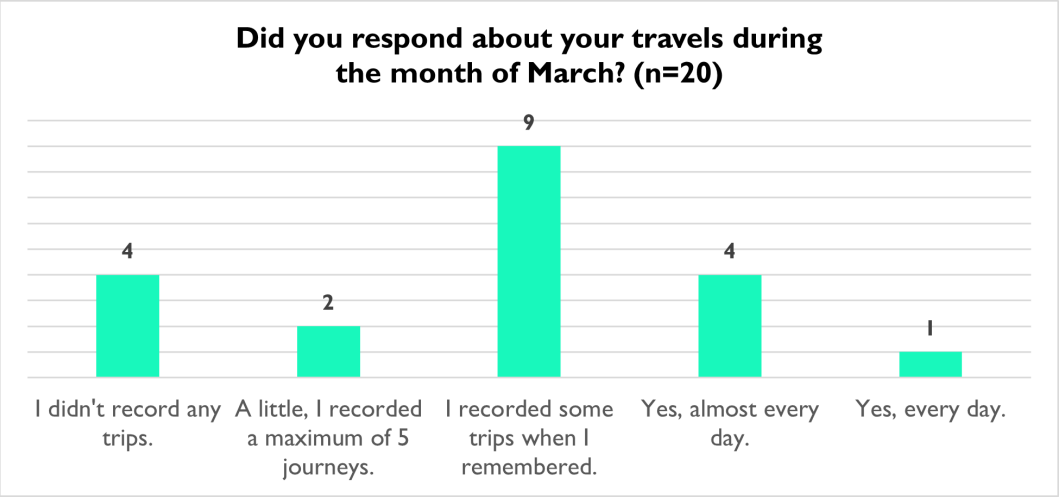


Chart 5 – Frequency of responding to the diary

The multiple-choice question about the reasons for not participating allowed participants to select more than one option and provide additional reasons. The two main reasons were not seeing the stories and finding the system difficult (Chart 6). The Instagram algorithm was identified as an issue, as it did not display stories to all followers, causing some participants to miss shared content and subsequently forget to respond to the diary.

Toward the end, they were also asked if they had any suggestions on how to increase their participation. One participant mentioned being confused by the system. With numerous subscriptions and notifications on their profile, they ended up not receiving the research content frequently. For them, it would have been easier if they had received it through WhatsApp. Another participant said, "Recording all daily trips is challenging due to extensive travel; perhaps if the questions were reduced, it would be easier."

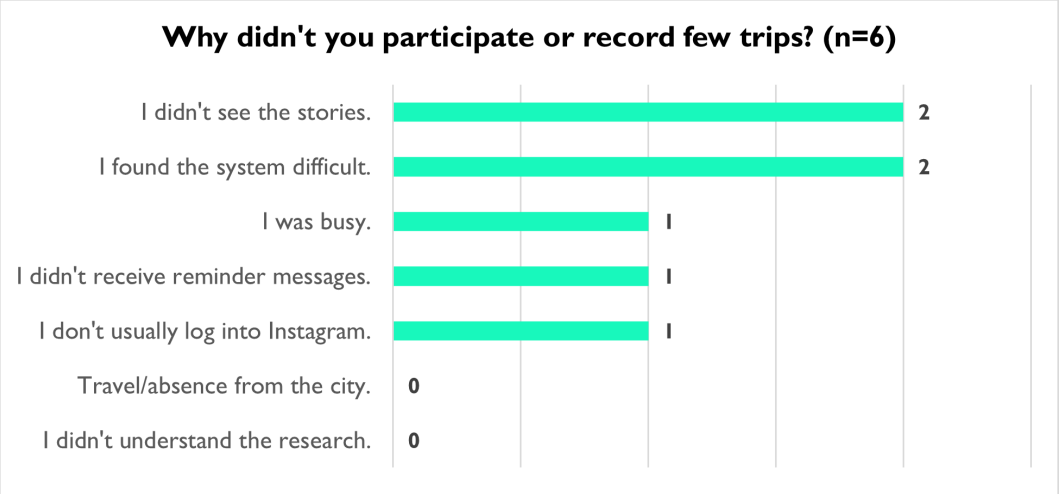


Chart 6 – Reasons for not responding to the diary

In their responses about the visibility of stories and fatigue in responding, participants were asked to agree (5) or disagree (1) with statements: "Whenever I logged into Instagram, I saw the research stories" and "I found it tiring to respond, and sometimes I felt unwilling" (Chart 7). The average score for seeing the stories was 3.64, slightly above neutral. As the Instagram algorithm varies for each person, three people disagreed, likely not seeing the messages. Regarding fatigue, the average score was 2.50, indicating disagreement with finding it tiring. However, this response only came from those who passed the filtering question and responded; those finding it tiring might have dropped out without continuing.

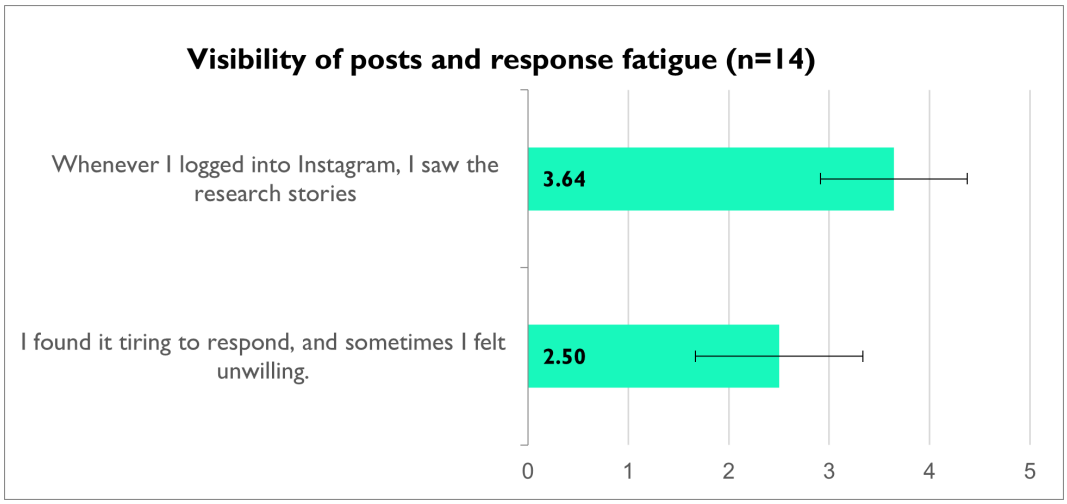


Chart 7 – Statements about visibility and fatigue

Participants who responded to the diary mentioned that their main motivations were the desire to contribute to the research and their belief in the importance of citizen participation (Chart 8). This may be attributed to the snowball sampling method, characterized by participants recommending others, creating a bubble of acquaintances. When participants are more impartial, the importance of participation might not resonate as strongly.

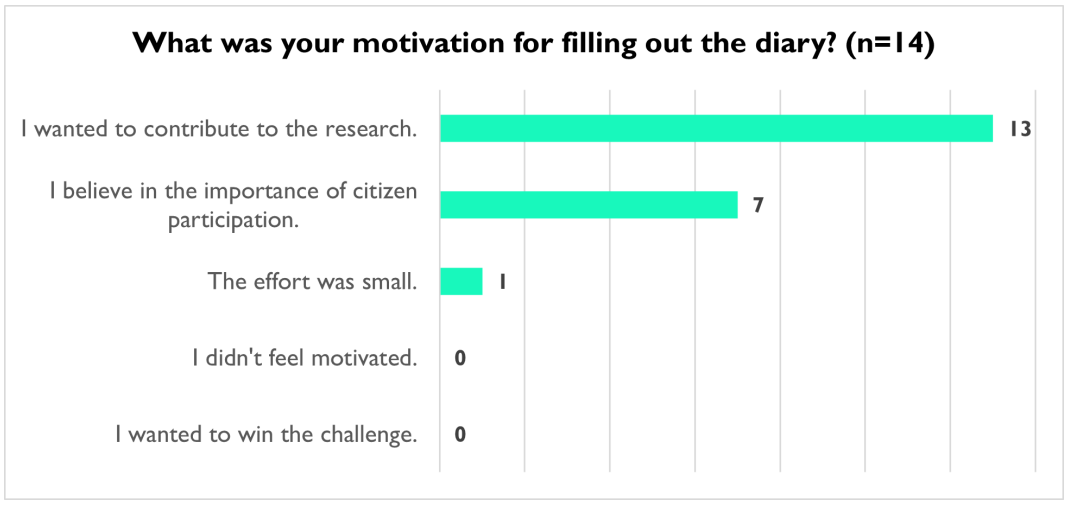


Chart 8 – Motivations for responding to the diary.

The question about the timing of diary entries allowed multiple choices (Chart 9). Participants typically responded when they saw the stories, when they remembered, or while commuting. Interestingly, two participants recorded elsewhere and later sent all past trips when accessing Instagram. In the final open

suggestion question, one participant preferred responding only through chat instead of answering each story, while another criticized the repetitive nature of short and frequent trips during the research period, suggesting a different mode of recording.

Chart 9 – When entries were made

We presented statements to respondents using a Likert scale ranging from 1 (disagree) to 5 (agree). Scores above three indicated a positive response, below were considered negative, and "three" was neutral. The statements were related to the diary's overall usability, communication, and gamification techniques.

To ensure the reliability of data, we employed a triangulation approach by generating multiple questions on the same topic. This method, recommended by Tullis and Albert (2013), helps obtain more robust data by exploring various angles of assessing the attribute. The feedback regarding the diary system was predominantly positive, as illustrated in Chart 10. Yet, in Chart 11, we took an average of responses to usability statements for a comprehensive analysis, aiming to gauge participants' overall reactions. We further cross-referenced this data with responses related to their experience using Instagram, intending to discern whether difficulties in responding to the diary were linked to their familiarity with the social network.

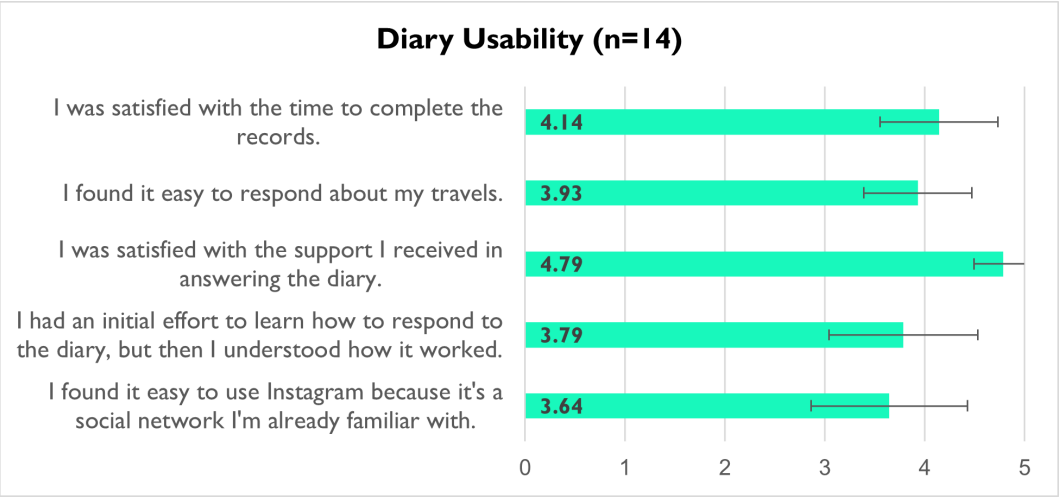


Chart 10 – Statements about the overall usability of the system

Our observations revealed a correlation between the frequency of Instagram usage and participants' usability ratings. Generally, those who reported using Instagram more frequently tended to provide higher usability ratings. Notably, the usability rating of individuals who rarely logged in or could not recall their usage frequency was comparatively higher. It is worth noting that this category includes individuals who stated they could not remember their login frequency, not necessarily those who use the platform infrequently.

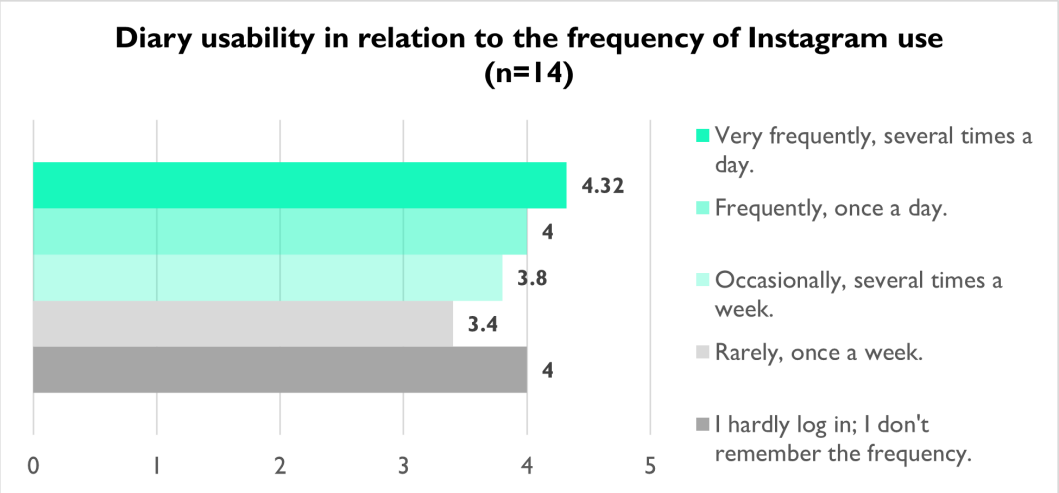


Chart 11 – Evaluation of usability correlated with participants' Instagram usage

In terms of the informational content disseminated, participants responded positively (Chart 12). The majority agreed with statements about the interest in traffic updates, weather information, data presentation, and statistical insights.

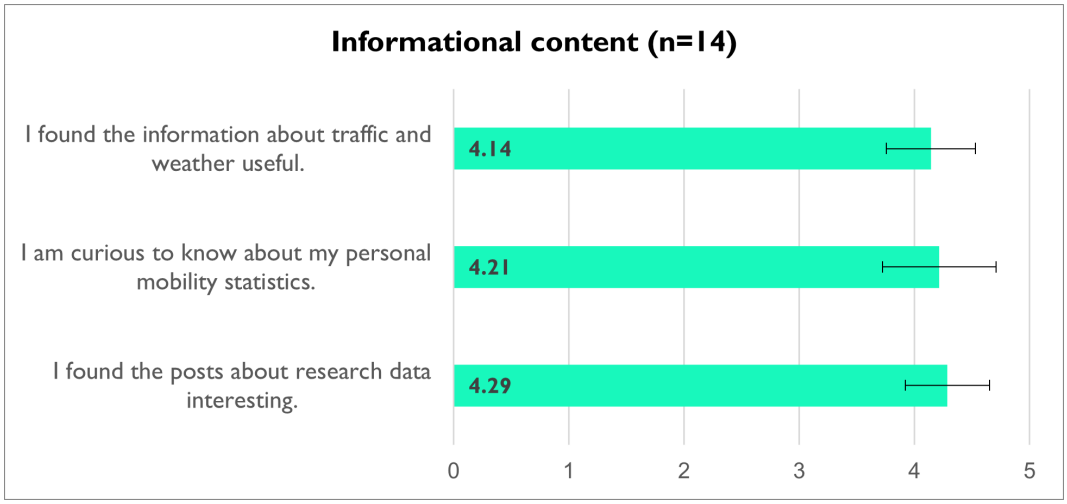


Chart 12 – Participants' feedback on communication-related statements

However, gamification elements, such as the quiz and participant ranking, did not generate high engagement among participants, as indicated by a more neutral rating (Chart 13). This aligns with the responses to the question about participants' motivation for diary engagement, as none mentioned a desire to compete or win a challenge.

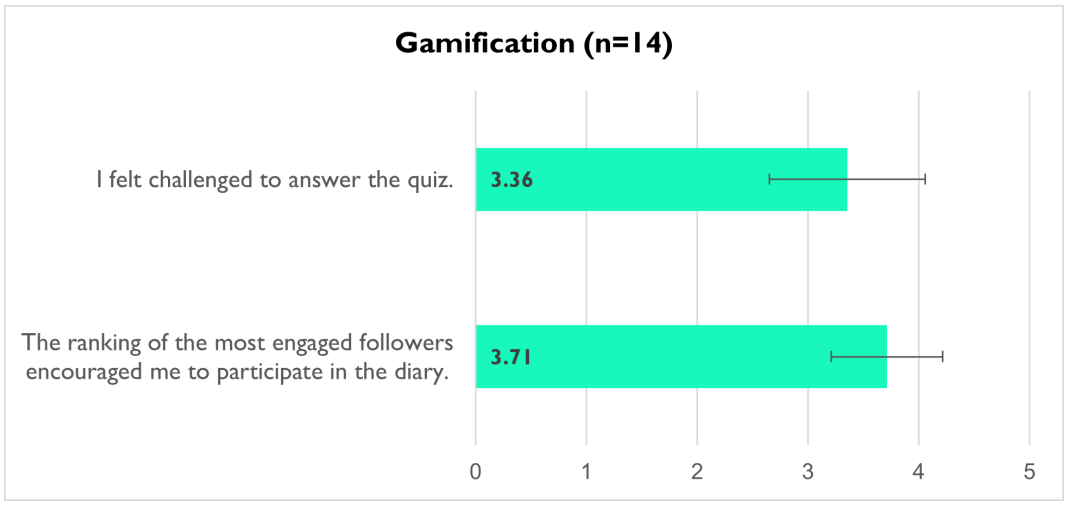


Chart 13 – Participants' feedback on gamification elements, including the quiz and ranking

In the final open-ended question about suggestions to increase participation, three participants commented on reducing the number of questions to streamline the registration of each trip. One participant suggested: "It would be very cool to visualize simple statistics/graphics of my travels during the study. I think it would

encourage more participation in the study and would be a counterpart from the study to the participants." Thus, the personalized art could be shared incrementally among participants rather than once at the end of the study, increasing transparency and identification with the theme.

5.2.3. Discussion

Our research questions aimed to uncover the effects of weather on urban mobility in Rio de Janeiro and explore how a diary study using Instagram could enhance public engagement. Design, as emphasized by Manzini, Fuster and Paez (2023), can play a pivotal role in city-making by understanding and reinforcing the complex network of relationships within a city. The creation of a diary through a commonly used social media platform facilitates information sharing.

Despite Instagram's popularity in Brazil, our recruitment survey neglected to inquire about the frequency of Instagram use, which proved to be a barrier for some participants. This oversight in the sampling process hindered engagement and posed difficulties for those less familiar with the platform.

The algorithmic limitations of Instagram, which did not deliver content to all users, prompted us to share weather and traffic-related posts to boost participant engagement. However, gamification techniques, such as participant rankings, failed to motivate citizens to register their trips and enhance their involvement in the study.

The gamification aspect faced challenges, possibly due to the lack of compelling incentives. As an academic research project without substantial funding, we could not offer substantial rewards. However, for future research endeavors, partnerships with other institutions could potentially introduce more appealing benefits for participants.

One explored concept involved introducing playfulness into daily activities, such as commuting. Mews (2022) suggests that social encounters or play can offer a brief respite from the regular routines of daily life, disrupting the established order of activities. Recognizing the link between everyday life and play involves viewing play as an activity that reveals spatial tensions by deviating from routine activities in space.

Some participants mentioned that nothing special had occurred, leading them

to refrain from recording certain events. The primary goal of the diary was to capture all entries, even those that might not have seemed special to participants but could hold relevance for the research. Effective communication is crucial, emphasizing the clear and transparent presentation of the research objectives and how the collected data will be useful. Without this clarity, there is a risk of falling into a pattern of repetition, potentially leading to participant disengagement.

The diary study conducted on Instagram brought to light both specific limitations and significant findings. First and foremost, the reliability of Instagram analytics came under scrutiny due to instances of inaccurate data. This raised concerns about the precision and dependability of the platform's analytical tools. Furthermore, the study uncovered challenges associated with certain tools designed for personal use on Instagram, which were unavailable for business purposes. This limitation hindered the automation of messages, presenting a notable obstacle—particularly in cases where scheduling stories with polls was not feasible.

AI played a crucial role throughout the process by suggesting content, generating posts, creating quizzes, crafting text and participant images, generating names, and identifying patterns. As highlighted by Xu (2019), professionals in Human-Computer Interaction (HCI) are adept at using HCI methods to identify usage scenarios. They can harness AI and big data to model real-time user behaviors and create digital user personas for understanding potential user needs and real-world usage scenarios.

5.3. Social network analysis

In the preceding section, we presented data derived from a diary involving a small group of individuals. However, incorporating diverse voices makes the observation of a phenomenon more objective and impartial. According to Ciuccarelli, Lupi and Simeone (2014), processes of collecting, analyzing, and visually representing social media data allow for the emergence of multiple perspectives at the urban level. For the authors, this multiplicity contributes to a more objective representation of the city.

Research-based on Twitter has witnessed significant growth since 2006 and is anticipated to continue expanding (Menichinelli *et al.*, 2023). Twitter also serves as a platform for discussing climate change. Lundgaard (2021) explores the

potential of social media to raise awareness about various issues and its role in ongoing debates regarding global challenges and social responsibility areas. For the author, this is particularly critical, given that social media fosters a dynamic and interactive environment, shaping new influential dynamics in communicative interaction. Debates about societal challenges extend beyond political systems and are embedded in decentralized democratic processes involving non-state actors.

Our methodology comprised analyzing the sentiment expressed in tweets related to transportation and then cross-referencing this sentiment with the maximum temperatures recorded on the respective day of the post. A more comprehensive explanation of this process will be presented in the subsequent section.

5.3.1. Methodology

The third method adopted for collecting data in our research involved a comprehensive analysis of Twitter, a rich source that could offer insights into public sentiment and discourse. To achieve this, we secured access to the complete Twitter archive by acquiring an academic account through the API (Application Programming Interface). This API serves as a robust toolkit, providing developers with the necessary tools and protocols to interact with the Twitter platform, access its extensive data, and perform various operations programmatically.

In the initial stages of our data collection process, we employed the Twitter Downloader tool, a solution for extracting relevant information from the platform. However, unforeseen changes within the company led to the unavailability of this tool. Undeterred, we adapted our approach, transitioning to the Postman[15] platform (Figure 22), which comes highly recommended by the Twitter developer community. This shift ensured the continuation of our data collection efforts, allowing us to maintain a consistent and reliable stream of Twitter data for our analysis.

[15] https://www.postman.com/

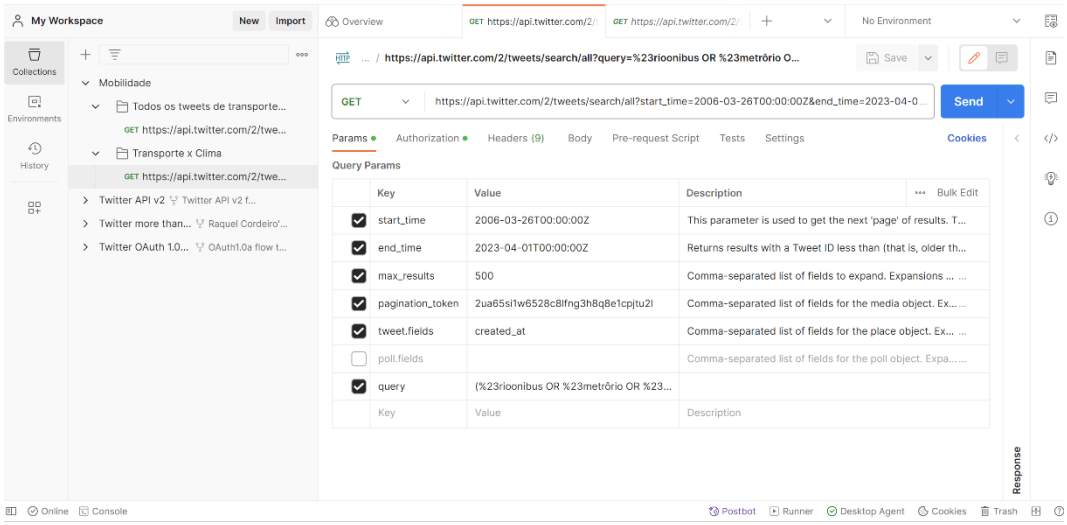


Figure 22 – Capture of the Postman application interface utilized for making requests to retrieve tweets

A search was conducted for tweets containing specific transportation-related hashtags such as #rioonibus, #metrôrio, #BikeRio, #CCRBarcas, #UberRJ, #TaxiRio, #SuperVia, #vltcarioca, and #BRTRio within the last ten years, resulting in 36,016 tweets. Subsequently, the tweets were filtered using weather-related keywords extracted from the most common subjects commented in the diary study, such as sol (sun), chuva (rain), nublado (cloudy), calor (heat), frio (cold), ar-condicionado (air-conditioning). The query was limited to tweets in Portuguese and excluded retweets, resulting in a reduced dataset (Table 8). So we collected from the entire Twitter archive from 2016 until 31 March 2023 and had 3,514 results.

PARAMETERS	**QUERY**
Hashtags	(#rioonibus OR #metrôrio OR #BikeRio OR #CCRBarcas OR #UberRJ OR #TaxiRio OR #SuperVia OR #vltcarioca OR #BRTRio)
Climate-related terms extracted from the diary study	(sol OR chuva OR Ensolarado OR Nublado OR Chuvisco OR calor OR frio OR alagamento OR fresco OR condicionado OR ar OR tempestade OR clima OR temperatura OR Agradável OR Abafado OR Quente OR sombra OR orla OR graus OR arborizada OR chovendo OR chover OR céu OR gelando OR infernal OR ventania OR árvore)
Period	From: 2006-03-26T00:00:00Z To: 2023-04-01T00:00:00Z
Language	Portuguese
Restriction	retweet

Table 8 – Search query employed to retrieve information, specifying key parameters

The sentiment analysis phase constituted a crucial component of our methodology, offering a nuanced understanding of the sentiments expressed in the collected tweets. Sentiment analysis, also referred as opinion mining, is a sophisticated technique employed to scrutinize sentiments and opinions articulated in written language, specifically in the context of comments on social media platforms. This method employs natural language processing (NLP) to systematically identify, extract, quantify, and study the affective states and subjective information conveyed in textual content (Liu, 2012).

To conduct sentiment analysis, there are diverse data processing codes and tools accessible on public platforms like GitHub, making programming resources easily usable. Sentiment analysis demands custom code and training on texts in a specific language. For this study, we opted for a multilingual XLM-roBERTa-base model[16], trained on a large dataset of nearly 200 million samples. This model was focused on sentiment analysis and incorporated datasets in eight languages.

Barbieri, Anke and Camacho-Collados (2022), highlighted the significance of this multilingual approach. This model, trained on data in over thirty languages, was made available to support multilingual Twitter research. It facilitated polarity detection, categorizing comments as positive, neutral, or negative and assessing reliability, enabling a thorough analysis of sentiments in the Twitter data.

The outcomes of this sentiment analysis, applied to the Twitter data related to urban mobility in Rio de Janeiro, provided insights into public sentiment and perceptions concerning weather-related conditions. By categorizing comments based on their sentiment and reliability scores, our analysis added depth to the understanding of how individuals perceive and express sentiments regarding urban mobility in the context of varying weather conditions.

5.3.2. Results and analysis

The process encountered obstacles due to structural adjustments within the involved companies, which had an impact on the research dynamics. Despite these challenges, the analysis provided insights into public sentiment regarding urban mobility in Rio de Janeiro.

Signing up for the Twitter API presented its own set of complexities,

[16] https://github.com/cardiffnlp/xlm-t

involving technical terms and specific requirements. Acquiring an academic account with access to the complete Twitter archive was instrumental; however, the website's limitation of 500 tweets per request necessitated a pagination strategy to download all the required posts efficiently.

The sentiment analysis brought to light an interesting trend on Twitter, a platform often utilized for criticism. The majority of the posts exhibited a negative sentiment, although there was a notable exception in the case of bicycle-related content, where the prevailing sentiment was positive (Figure 23).

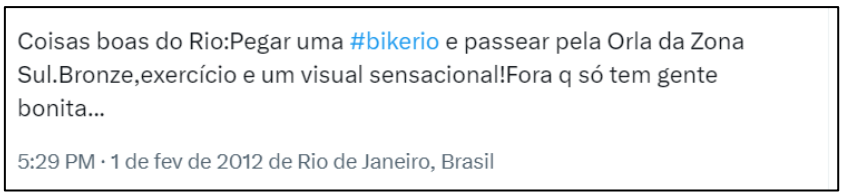


Figure 23 – Bicycles have more positive reviews, as seen in this post: “Good things about Rio: Taking a #bikerio and cycling along the South Zone waterfront. Sunbathing, exercise, and a sensational view! Plus, there are only beautiful people...”

One notable observation was the sentiment analysis's struggle with identifying sarcasm, leading to instances where seemingly positive comments were incorrectly classified as negative. This is exemplified in Figure 24, where the confidence score becomes crucial in gauging the accuracy of the sentiment analysis, as illustrated in Figure 25 with a higher score.

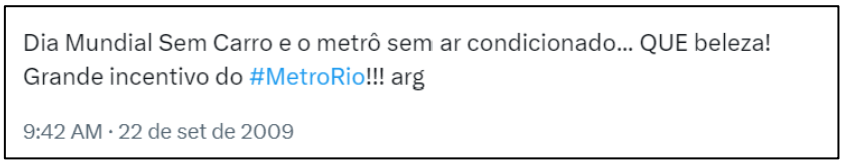


Figure 24 – The sarcastic tweet was rated as positive with a score of 0.87: “World Car-Free Day, and the subway without air conditioning... How wonderful! Great encouragement from #MetroRio!!! arg.”

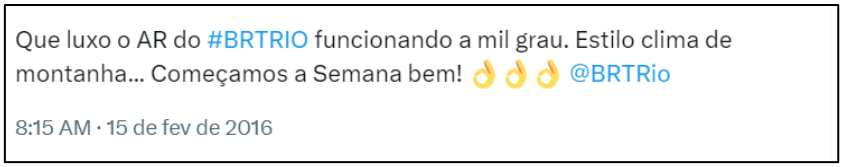


Figure 25 – Positive comment with a score of 0.92: “How luxurious is the air in #BRTRIO, working at full capacity. Like a mountain climate... Starting the week off right!”

Despite these challenges, discernible patterns related to transportation modes emerged from the sentiment analysis. The analysis identified several subjects of criticism, offering awareness that authorities could leverage for improvement. Figure 26 illustrates a user sharing a photo to highlight an issue with the ferries, emphasizing the practical application of sentiment analysis in understanding public concerns.

Figure 26 – Negative tweet with a photo exposing 2 ferries with air conditioning out of service, and the company puts an old and hot ferry into operation during peak hours in the scorching 40-degree Rio de Janeiro summer

After analyzing sentiments, we enriched our dataset by adding details about the maximum temperature recorded on the day of each post (Chart 14). Table 9 presents the percentage of each sentiment, considering comments related to the total of each transportation mode. The findings showed a significant focus on tweets about the metro and train systems, surpassing discussions on other modes of

transportation. This concentration indicates specific areas of increased public interest and concern in the field of urban mobility. The inclusion of weather-related data not only provided an additional dimension to our dataset but also enhanced our understanding of contextual factors influencing sentiments expressed on Twitter.

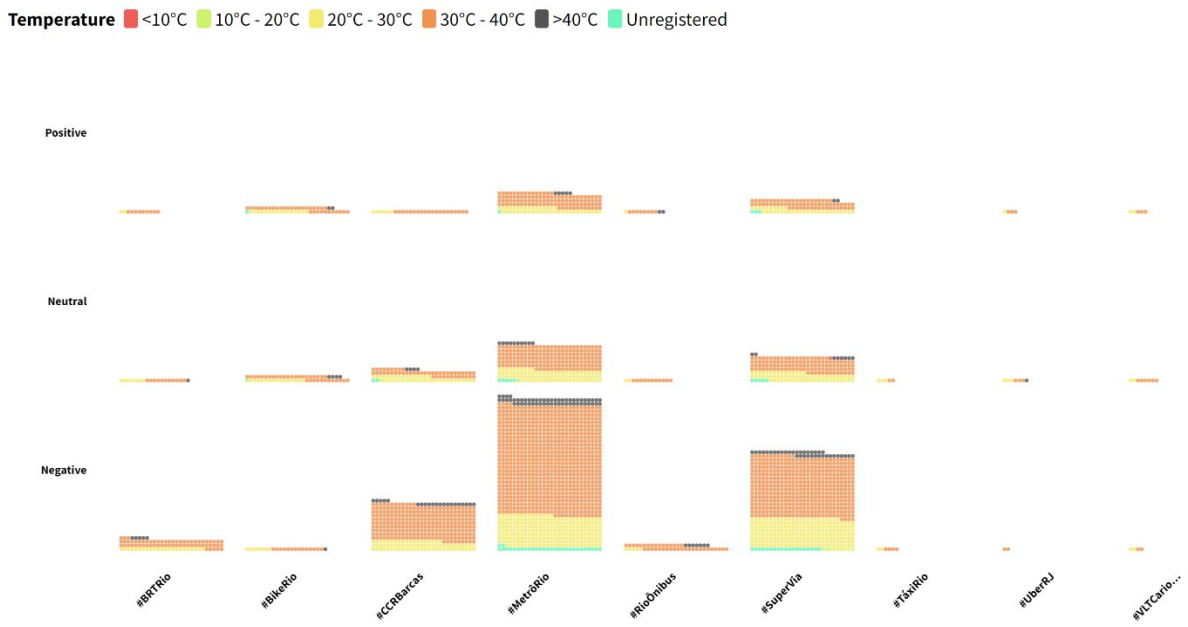


Chart 14 – Absolute numbers of tweets grouped by hashtags and sentiments, color-coded by temperature range.[17]

HASHTAGS	NEGATIVE	NEUTRAL	POSITIVE	TOTAL
#MetrôRio	72%	18%	10%	1602
#SuperVia	71%	19%	10%	1054
#CCRBarcas	75%	20%	5%	492
#BikeRio	17%	42%	41%	128
#BRTRio	75%	16%	9%	122
#RioÔnibus	68%	17%	15%	75
#VLTCarioca	24%	47%	29%	17
#UberRJ	15%	54%	31%	13
#TáxiRio	55%	45%	0%	11
Total	70%	20%	10%	3514

Table 9 – Percentage of tweets gathered based on specific hashtags, and analysis of sentiment

[17] https://public.flourish.studio/story/2075536/

5.3.3. Discussion

Social media platforms serve as rich repositories of information and can be analyzed in various ways. Ciuccarelli, Lupi and Simeone (2014) outline several areas commonly explored on these platforms, presenting avenues for future research with alternative focuses:

- **Characterizations of Geographic Areas:** Utilizing sentiment analysis techniques allows the identification of emotional attitudes toward cities, specific neighborhoods, or urban infrastructures. While our study is focused on sentiment related to transportation, future research could explore sentiment variations across different neighborhoods, providing insights into the inequality of access within the city.
- **Temporal Dimension:** Analyzing how users' contributions change over time offers insights into the dynamics of urban life. Our study spanned 15 years, examining variations across different weather conditions. Exploring temporal patterns enables the identification of peak activity, user movement patterns, and potential shifts in sentiment based on factors like weather or modes of transportation.
- **Places Identities and Relationships Among Geographic Areas:** Analyzing user profiles on social media can predict characteristics of urban places, such as gentrification areas or emerging places. Understanding patterns of mobility among different user groups contributes to a nuanced understanding of urban dynamics.
- **Emerging Behavior:** Social media often witness bottom-up initiatives in response to unmet needs. Can the lack of infrastructure or services be detected through users' online complaints? Our study has identified numerous transportation-related issues that could be monitored for city improvements.
- **Political Attitudes:** Examining reactions to new policies on social media provides insights into public acceptance or dissatisfaction. Monitoring public sentiment regarding policy interventions, such as changes to transportation systems, can inform governance and decision-making.

Social media platforms pose challenges due to the influence of algorithms on

public opinions and users' content-sharing behaviors. Lundgaard and Etter (2023) highlight the significance of the "input" dimension, referring to the design of these platforms. The design encompasses information architecture, underlying algorithms, and content moderation, shaping the structure of conversations and influencing everyday discourse. For them, it is crucial to investigate the roles algorithms play in opinion visibility and how they structure conversations, as these factors impact the dynamics of everyday talk on social media.

The presence of bots, automated posts, and fake news raises concerns, impacting the quality of online debates and prompting significant criticism. Lundgaard (2021) emphasizes that online discussions often become emotional and, at times, irrational, leading to a perceived decline in debate quality. Research indicates that social media can foster polarization and fragmentation, not only diminishing the quality of discussions but also exerting a substantial impact on society. The author underscores the necessity of further investigation to understand the applicability and limitations of early internet research promises in the context of contemporary social media discussions on global challenges.

We utilized hashtags related to transportation modes in Rio de Janeiro, thereby excluding numerous tweets discussing transportation without using the exact term. This approach was chosen to focus specifically on Rio de Janeiro, filtering out irrelevant tweets from other regions. Additionally, we did not specify geolocation due to many users not permitting such sharing, further reducing our sample size. Lundgaard (2021) has also noted this limitation, acknowledging that this approach may exclude tweets with misspelled terms or responses that do not include hashtags. While this method served our study's purpose, it is acknowledged that a more extensive data collection could have offered a more comprehensive and accurate representation.

Another significant concern pertains to ethics and privacy. In recent years, Lundgaard (2021) emphasized the criticality of ethics in social media research, particularly in studies relying on big data collected without users' knowledge. Accessibility alone does not confer ethicality. Lundgaard stresses the importance of upholding a high ethical standard, emphasizing respect for individuals' rights and privacy. Questions surrounding how informed consent is defined emerge as crucial ethical considerations in conducting research in this domain.

The limitation of social media platforms, including Twitter, lies in their

inherent sub-representation of the broader population, rendering them inherently niche-oriented. It's essential to recognize that any analysis conducted on social media is constrained to the subset of individuals actively participating on the platform. This inherent bias in the user demographic presents a challenge, as the samples extracted and analyzed may not accurately reflect the diversity and nuances of the entire population (Hardt and Glückstad, 2024).

Therefore, complementing Twitter analysis with other research methodologies, not only enriches insights but also contributes to the training of automated analysis models. Integrating survey data with social media classification techniques serves to elevate the overall quality of the analytical framework for social media. As highlighted by Hardt and Glückstad (2024), surveys offer valuable datasets for training NLP systems, improving their ability to make nuanced inferences about travel preferences. For them, advancements in NLP technology, especially with large language models, may enable future applications, allowing marketing managers to perform detailed segmentation or even individualized targeting of potential travelers.

This study was tailored to the needs of this thesis, exploring its limitations and potential. Adapting it for other studies is challenging, requiring a case-by-case analysis. As Ciuccarelli, Lupi and Simeone (2014), pointed out, there is no universal approach for social media research. Varied urban contexts and research questions require careful consideration of which indicators to extract from social media data and which analysis strategies to apply.

Menichinelli *et al.* (2023) believe that Twitter and other social media platforms can be integrated into Service Design. By combining quantitative digital methods with traditional qualitative approaches, it is possible to generate data-driven personas, engage diverse stakeholders in designing services, and improve their quality. Additionally, Twitter data can be used to identify customer needs and preferences. In the following section, we will demonstrate how we used Twitter data, along with other research methods in a co-design workshop.

6.
Testing mixed data co-analysis[18]

Addressing complex climate issues demands innovative approaches that involve diverse stakeholders and integrate various data sources (IPCC, 2022). A central question arises: How can urban data be more accessible in a citizen participation process? To answer this query, we implemented a co-design process that integrates mixed data.

Employing data visualization and storytelling, we delved into the interplay between weather effects and urban mobility. This chapter explores participants' experiences during the workshop and their suggestions for enhancing activities. Detailed descriptions of the workshops, accompanied by visual representations and proposed activities, are provided. Additionally, we present the results from the mobility experience and the user journeys developed by participants for each mode of transportation.

6.1.
Methodology

We conducted a workshop with an experimental approach to explore mixed data co-analysis. This workshop merged quantitative urban data with qualitative insights from the last chapter. The workshop had a central goal: to delve into the relationship between weather impacts and urban mobility by combining various data sources and promoting collaborative problem-solving among participants.

The participants provided their consent by signing the form (Appendix K). Led by two facilitators, they co-analyzed mobility data using digital and physical tools, coming together to discuss weather-related behavioral patterns (Figure 27). Initially, we conducted a pilot workshop to refine the format, adjusting aspects like timing and visual aids, which led to two more workshops—one at the ServDes Conference (Cordeiro and Motta, 2023) and another in a design class at PUC-Rio with undergraduate students. According to the results of the first exploratory phase,

[18] This chapter was partially published at the Design Research Society Conference, Boston, 2024.

leveraging existing events facilitates citizen participation. Hence, we hosted workshops at the university involving professionals and students of design.

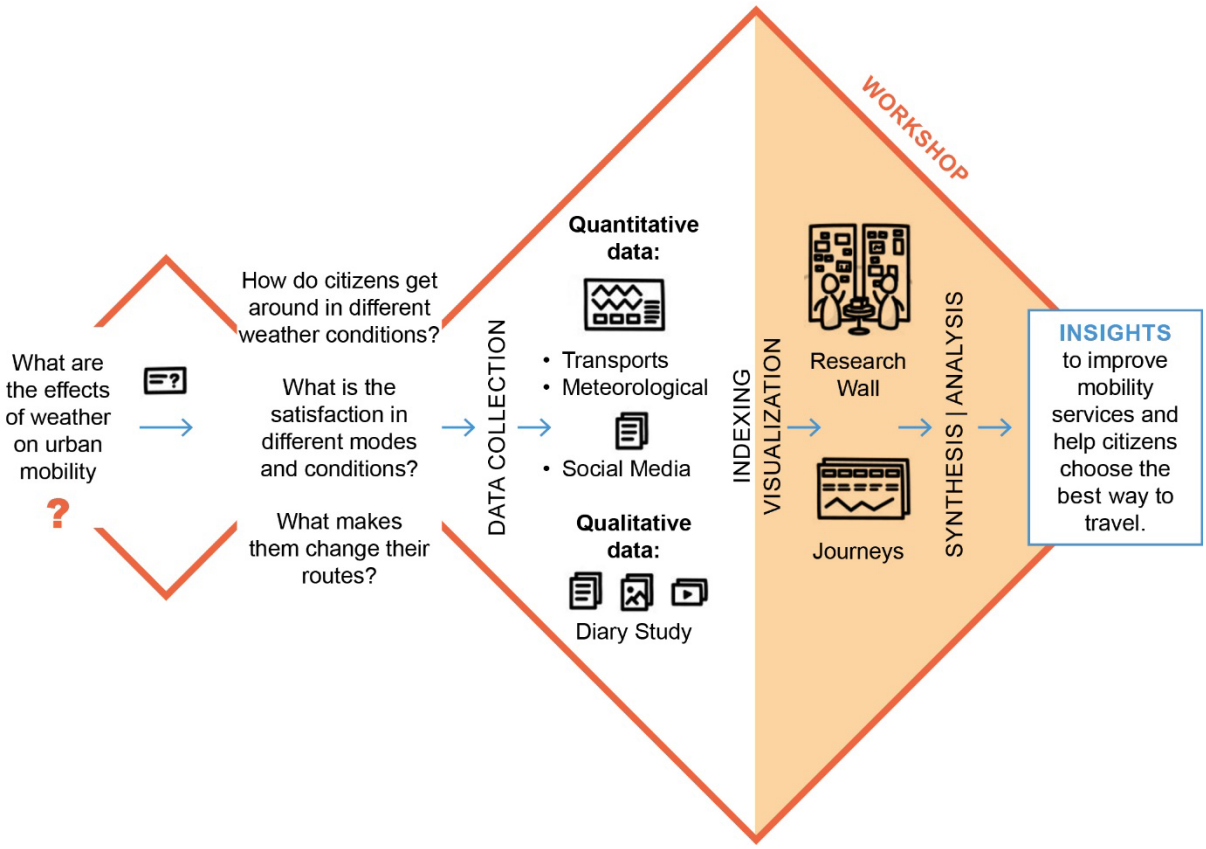


Figure 27 – Workshop scheme

Source: Adapted from the research process of Stickdorn *et al.* (2018).

The first workshop took place in July 2023, featuring 12 participants. We divided into four groups, each with three members, and the workshop lasted one and a half hours (Figure 28). In the second workshop, we grouped 17 participants into four teams (three with four members and one with five), and the workshop had two hours. Eight participants had prior experience with workshops, and six of them had even taken on facilitator roles, while 17 participants had either never engaged in such workshops or could not recall their participation. There were 24 women and 5 men. The presentation employed storytelling techniques and visual support, guiding participants through slides in Miro[19], which included graphics and videos that complemented the facilitator's narration.

[19] https://miro.com/app/board/uXjVNrVJtUU=/?share_link_id=609514640746

Figure 28 – Participants collaboratively analyzing data during the workshop

Source: Photo by the author

The warm-up activity allowed each participant to share and reflect on their commuting experience from home to the workshop venue, providing an initial understanding of their perspectives on urban mobility and establishing a foundation for subsequent activities. The facilitator chatted about the day's weather and asked attendees to stand. They divided the room into four tables, each designated for a city region, and then directed participants to the table representing their region of origin. A video, displayed on a slide from Google Earth, illustrates an aerial view of Rio de Janeiro, showing the route to the workshop venue (Figure 29). This movement highlights the spatial distribution across the city, addressing the geographic complexity and its potential specific profile when analyzing the city.

Colored strings, each representing a mode of transport, were affixed to the room's front, with captions displayed on the projected slide. Participants selected the color corresponding to their chosen mode of transport. This activity revealed the colors along the route. Subsequently, attendees expressed their trip experience - raising their arms for a satisfactory journey, bending them for an indifferent one, and lowering them if they did not enjoy it (Figure 30), akin to a humanized bar chart. With this information, we strategically organized participants into groups that would collaborate during the workshop, ensuring a diverse mix of origins and modes of transportation.

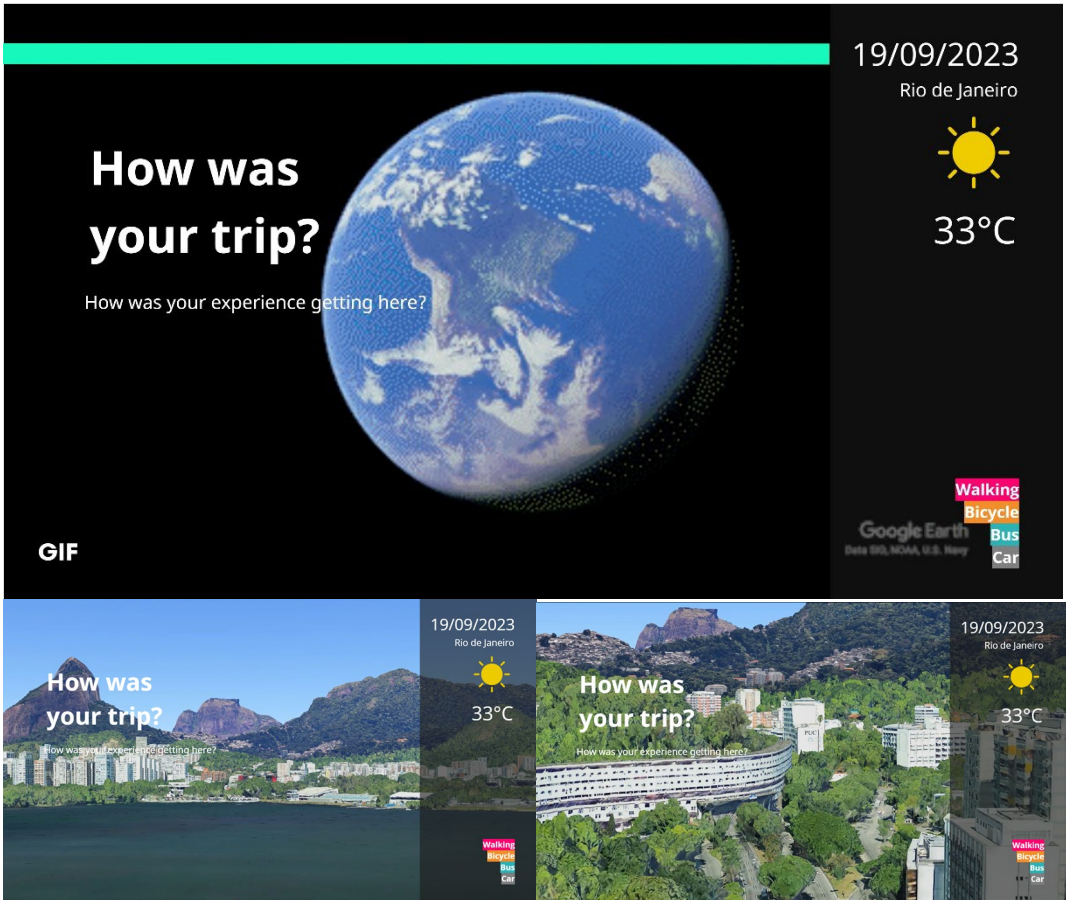


Figure 29 – Warm-up Activity: Zoom-in animation to the workshop venue. The slide included the date, location, temperature, and transportation mode colors[20]

Figure 30 – Tangible Data: Participants hold a string matching their mode of transport and raise their arms to indicate trip satisfaction

[20] http://tinyurl.com/4em8c9v7

Following the warm-up, the presentation introduced the context of global warming's potential impact on urban mobility. The slide displayed an image of vehicles on the street, gradually zooming in, accompanied by a graph with colored lines representing different years (Figure 31). The colors transitioned from cooler to warmer shades, reflecting the State of Rio de Janeiro's average annual temperature compared to the 1971-2000 average temperature. This graph is part of the "Show Your Stripes" [21] initiative by Professor Ed Hawkins at the University of Reading. This technique, known as data visceralization, leverages data to evoke sensations beyond visual elements. As D'Ignazio and F. Klein (2020) explain, visceralizations are data representations that engage the whole body emotionally and physically, a concept integrated at various points in the presentation.

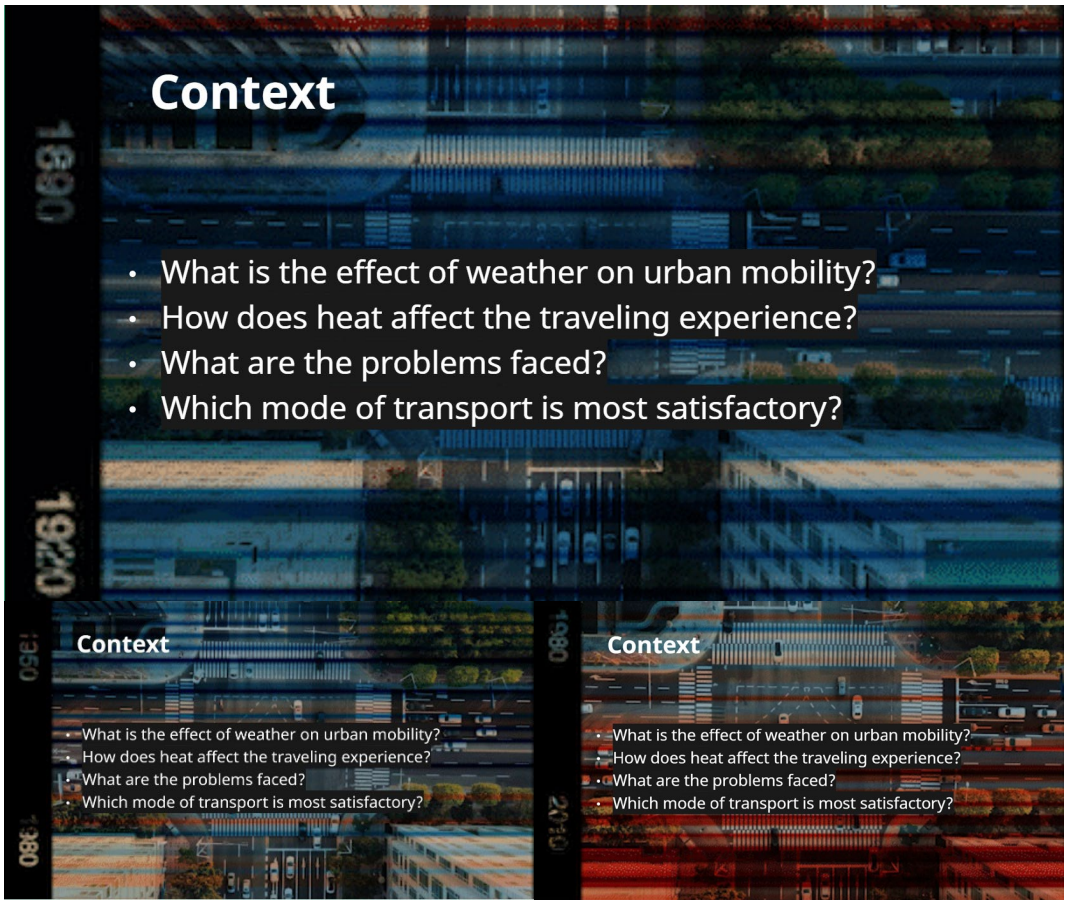


Figure 31 – Data Storytelling: Slide displaying questions while animation in the background features moving cars and a timeline with warming colors, exemplifying data visceralization[22]

[21] https://showyourstripes.info/l/southamerica/brazil/riodejaneiro
[22] http://tinyurl.com/3n8jm25v

The facilitator began to present various datasets. These datasets encompassed open city data, such as transportation and meteorological data, sentiment analysis from Twitter user reports, and qualitative data from a month-long diary study where participants documented their travel experiences within the city – those studies presented on the chapter 5.

The workshop adhered to a structured script to expand participants' comprehension, immersing them in a subject rooted in familiar data. Its objective was contextualizing "big data" using "small data" relevant to individual experiences. We conveyed the data through digital narratives, transitioning from personal journeys to a broader city-wide perspective, considering both geographical and temporal dimensions.

After this initial dynamic in which each participant reflected on their journey to the workshop venue, the slide presented a timeline initially focused on a single day. The facilitator then initiated a zoom-out movement, expanding the perspective to encompass the one-month duration of the diary study conducted in March. The image on the slide featured 19 participants (Figure 32), with AI-generated images and pseudonyms that preserved participant anonymity while personalizing the presented data. The characteristics of these AI-generated images closely resembled those of the actual participants.

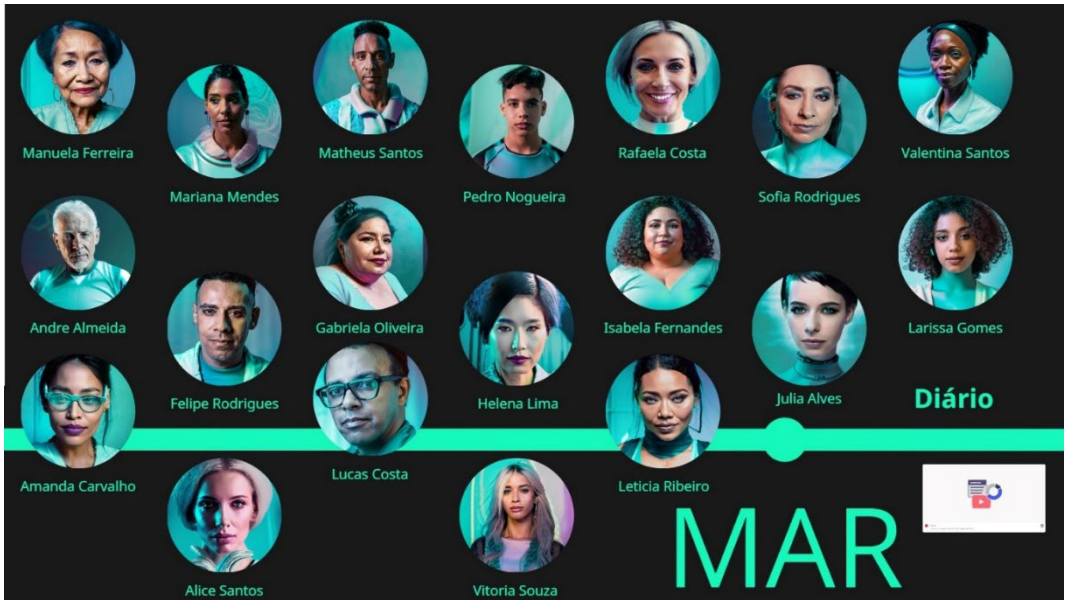


Figure 32 – AI-Generated Image and Pseudonym for Diary Study Participants

Data visualizations were crafted with the Flourish tool[23] and integrated into slides. The diary provided an overview of each participant's travel record, featuring data visualizations categorized by mode of transportation, satisfaction levels, thermal sensations, and comments (https://public.flourish.studio/story/2075555/).

Following this, the facilitator expanded the timeline view, encompassing the summer season. We unveiled open data obtained from government and transport companies during this phase. The initial slide illustrated the number of trips for each mode of transportation (Figure 33). Subsequently, an animation depicted a line graph charting the progression of a "transport race" over time, with variations occurring daily. We introduced another layer of information, showcasing the maximum temperature recorded each day and highlighting instances where the temperature exceeded 40°C (https://public.flourish.studio/story/2075548/).

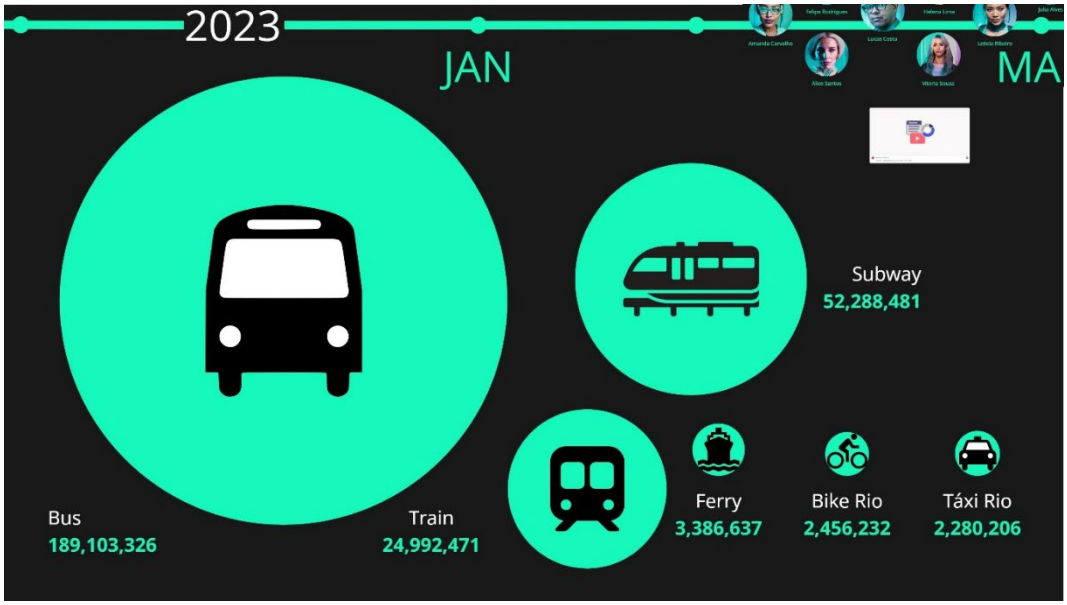


Figure 33 – Circles comparing summer transport mode usage

Finally, the timeline expands to the last 15 years, displaying the count of tweets featuring hashtags linked to transportation modes and climate-related terms (Figure 34). The graph illustrates data points, each denoting a post and categorized by hashtags, sentiment (positive, neutral, or negative), and the day's maximum recorded temperature (https://public.flourish.studio/story/2075536/).

[23] https://flourish.studio/

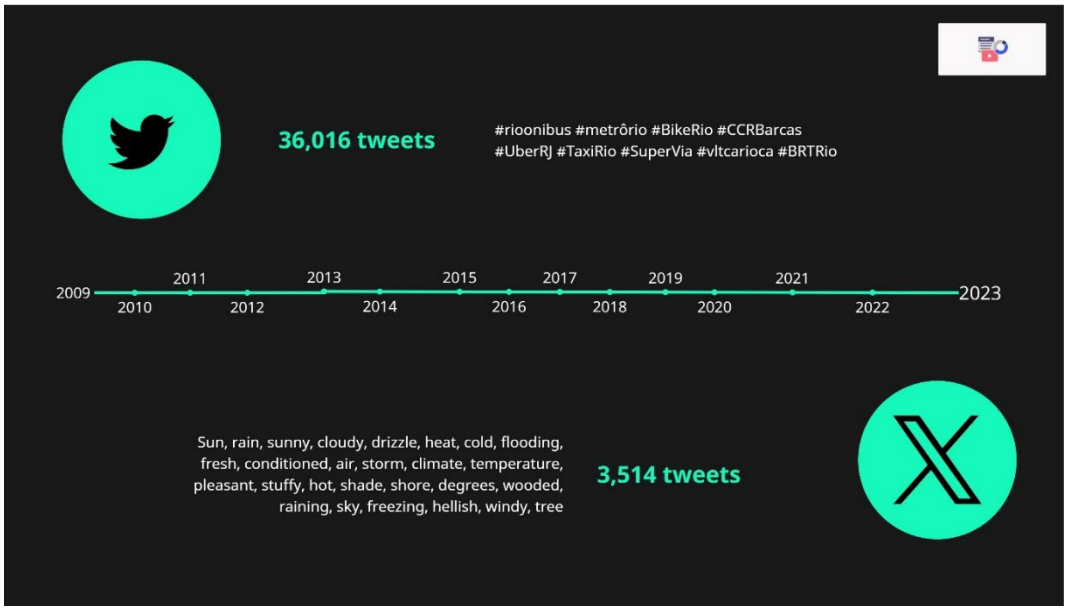


Figure 34 – Tweets with transport and weather-related hashtags and keywords in the last 15 years.

Following the data presentation, the facilitator initiated a discussion by posing the workshop question: “What are the positive and negative aspects of moving around Rio on warm days?” An illustrative slide featured a map of Rio de Janeiro, displaying the images and names of five participants from the diary study, along with their most frequently utilized mode of transportation and the underlying motivations for their journeys (Figure 35).

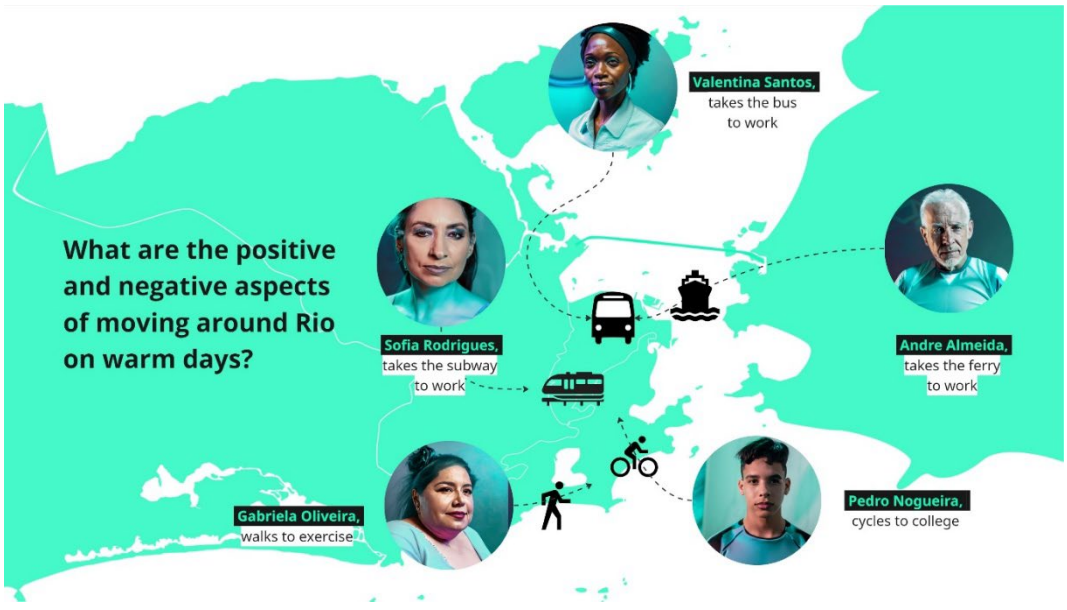


Figure 35 – Participant journeys map for analyzing Rio de Janeiro travel’s positive and negative aspects on warm days.

An interactive visualization tool (Figures 36 to 44) was purpose-built to facilitate collaborative analysis, catering to the diverse datasets. Within this framework, participants were organized into groups, allowing them to explore and engage with the data hands-on. This approach amalgamated various techniques identified during preliminary exploratory studies, resulting in a unique methodological fusion.

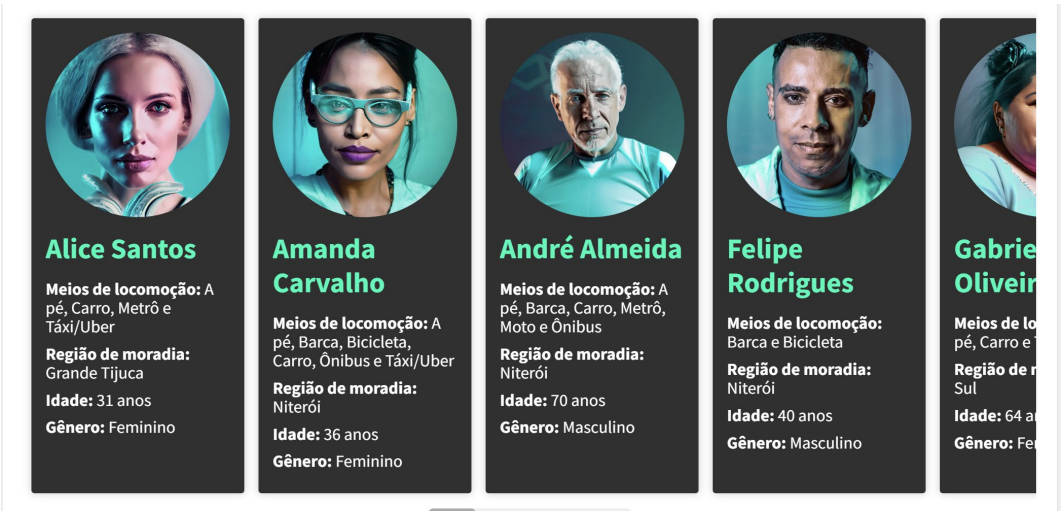


Figure 36 – Cards featuring diary participants' profiles

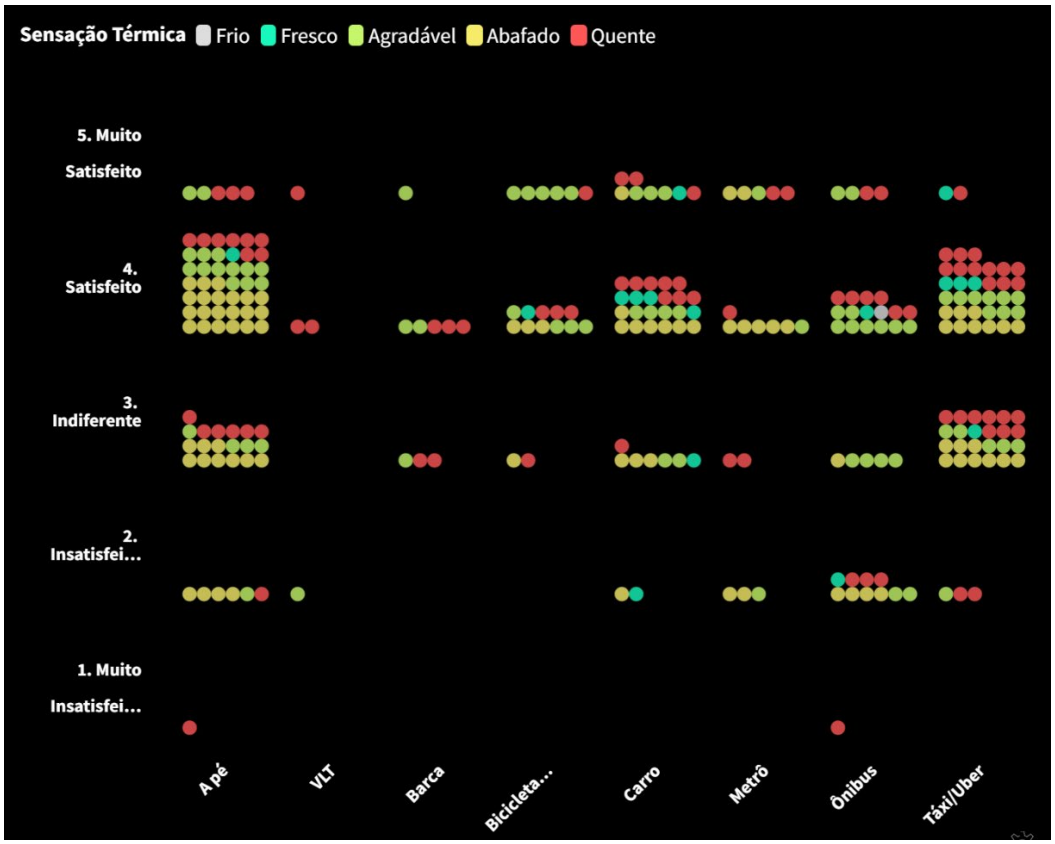


Figure 37 – Graphics illustrating absolute diary responses

Figure 38 – Diary travel comments, color-coded by reported thermal sensation and filtered by transportation mode

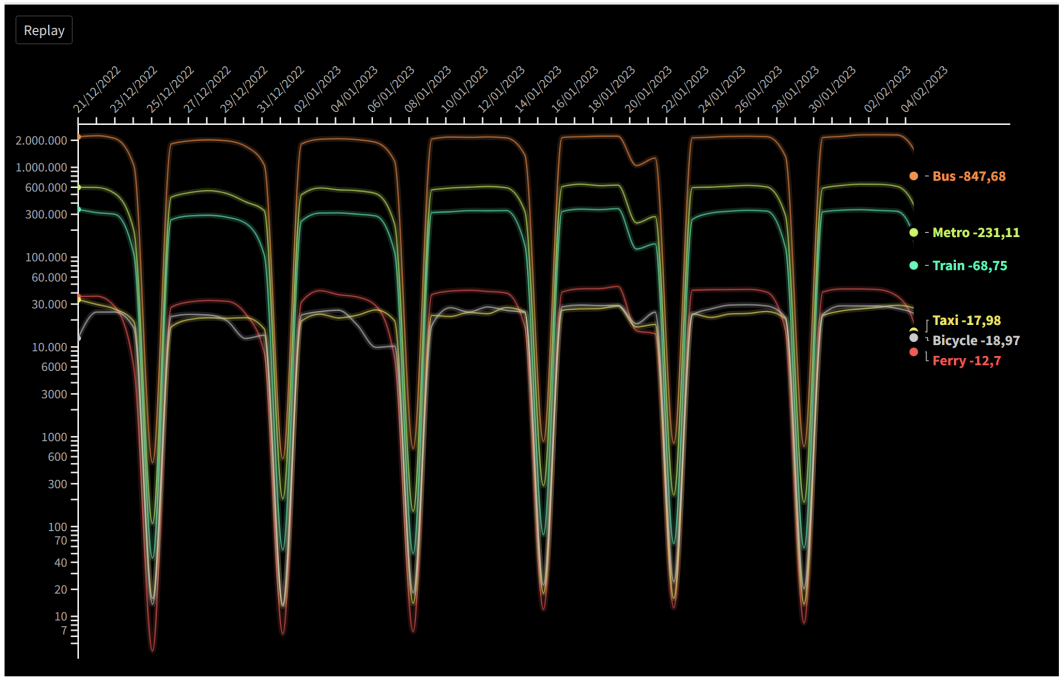


Figure 39 – Timeline race animation showcasing the number of trips by transportation mode in the summer

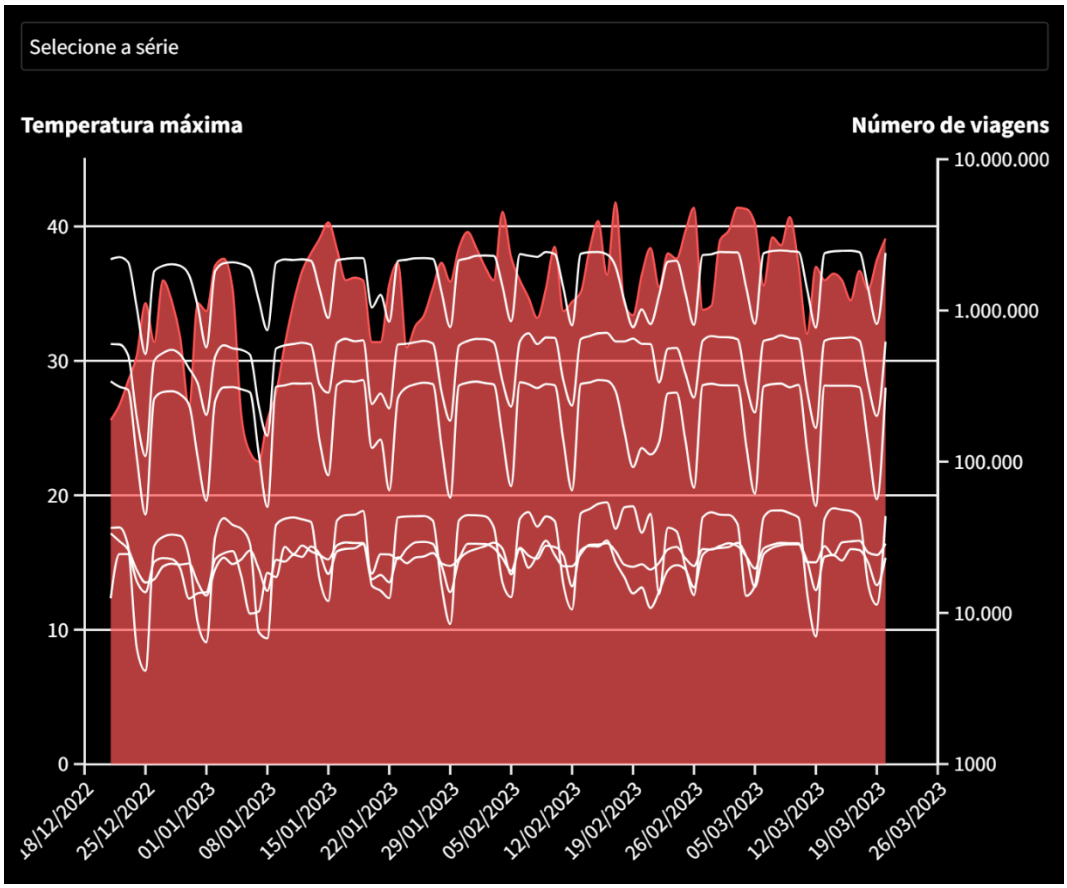


Figure 40 – Number of trips with the maximum temperature recorded each day

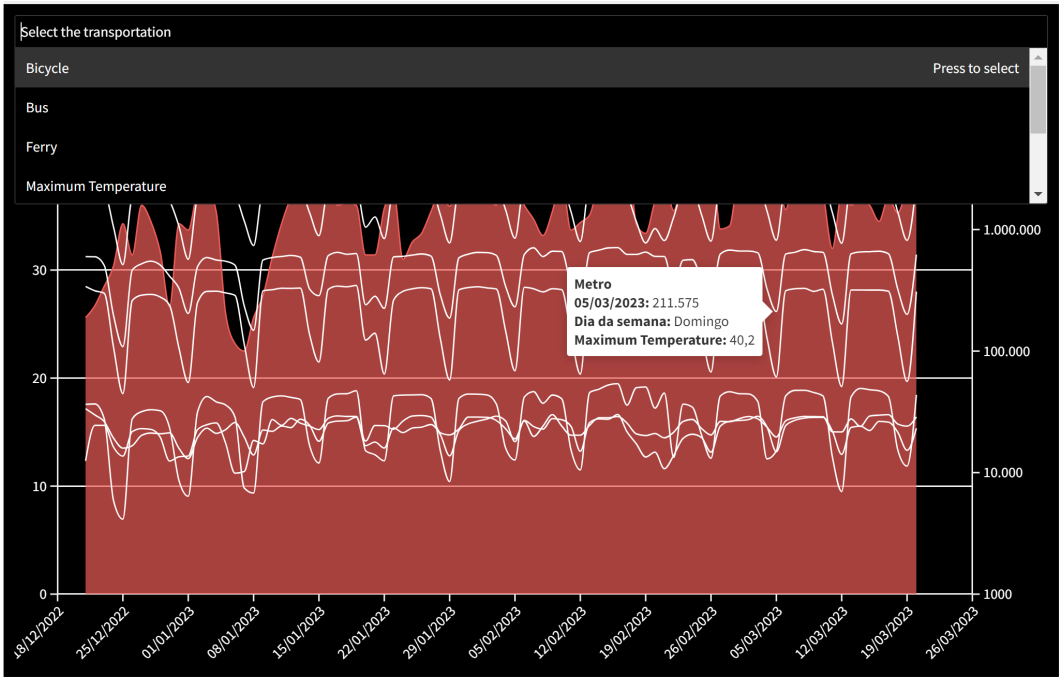


Figure 41 – Filter to select transportation. Pop up displays trips, day of the week, and temperature

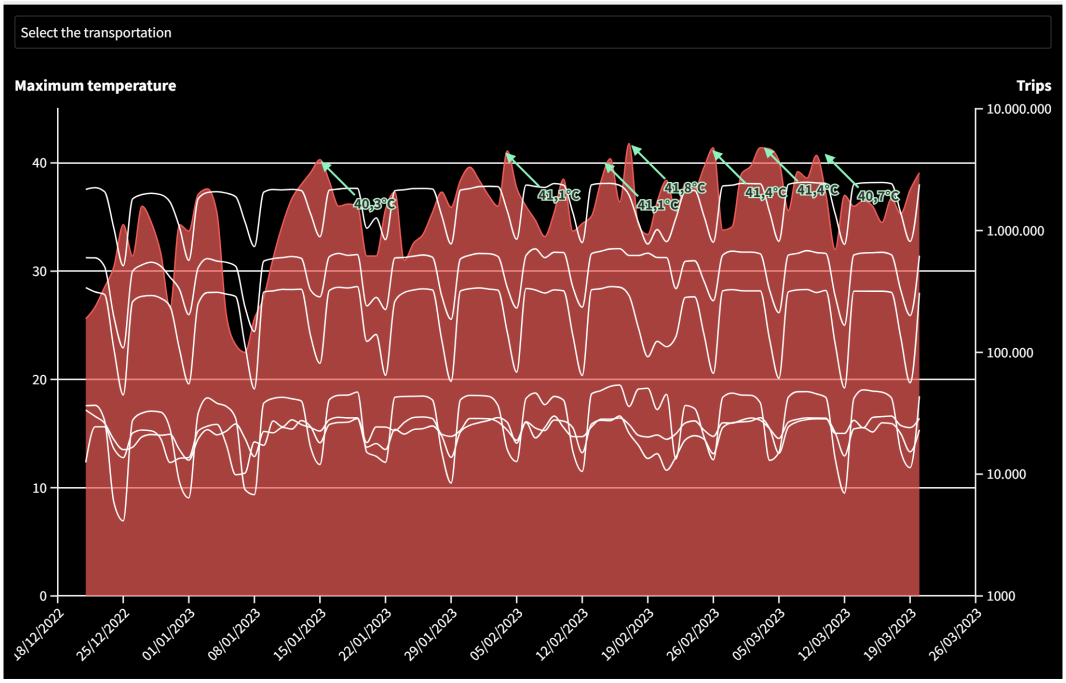


Figure 42 – Highlighting days with temperatures exceeding 40°C

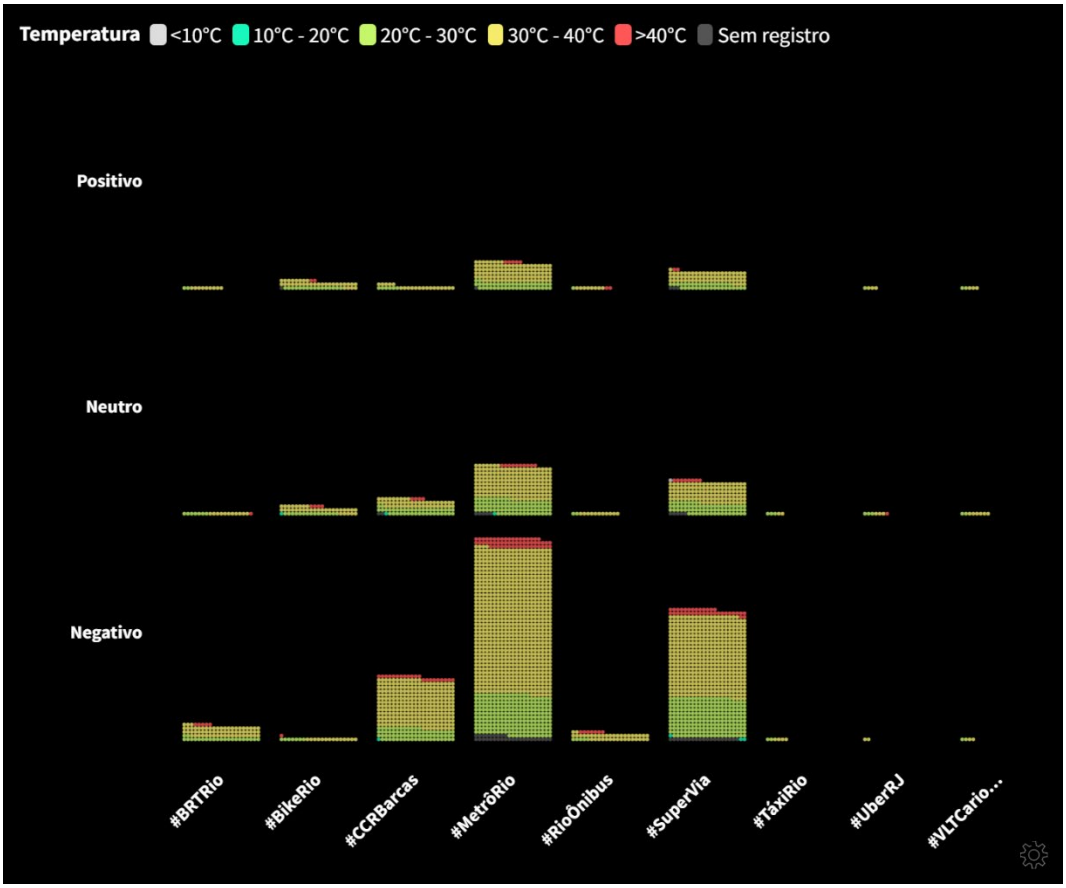


Figure 43 – Chart displaying the total number of tweets

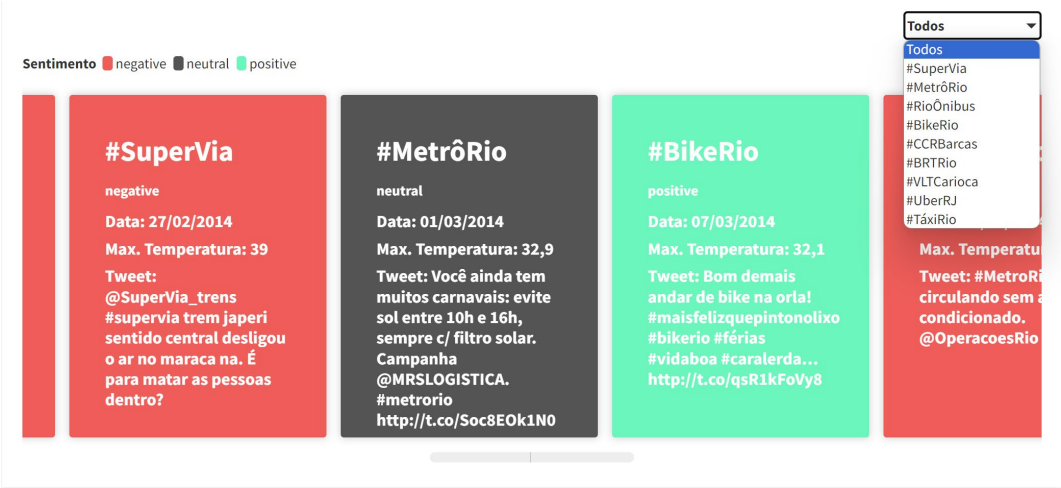


Figure 44 – Text shared on Twitter color-coded with detected sentiment and filtered by hashtags

Each group, representing a distinct mode of transportation, had a paper board displaying visualizations associated with that particular mode. On these boards, Lego bricks represented trips recorded in the diaries, with colors indicating perceived thermal sensations and positions denoting satisfaction levels. The boards also featured space for creating affinity maps and templates for empathy maps and user journeys. Additionally, participants received cards with open comments extracted from the diaries (Figure 45). Each table had a laptop that provided access to the interactive graphics presented earlier, allowing participants to filter and perform more in-depth analysis of the raw data.

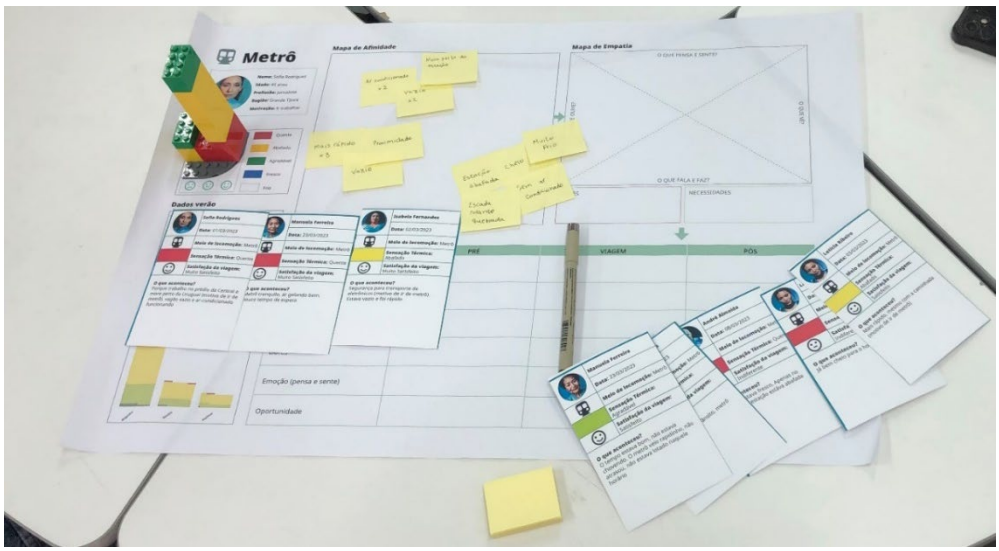


Figure 45 – Co-Analysis Activities: Boards featuring Lego brick representations of diary journeys, cards with comments, and areas for creating affinity maps, empathy maps, and user journeys.

While in groups, background music incorporating sounds from the Rio subway, ferry horns, bicycle, and bus braking played softly, enhancing the atmosphere for data analysis. In Table 10, we provide an overview of all activities that took place during a 2-hour workshop session. A detailed script can be found in Appendix L.

The initial activity, lasting 15 minutes, involved a comprehensive data review. Participants then extracted insights from this data and recorded them on Post-it notes, facilitating the creation of an affinity map. Subsequently, they had 5 minutes to categorize these Post-it notes. The following task was to construct an empathy map (Gibbons, 2018), where they considered what participants think, feel, see, say, do, hear, their pains, and their needs.

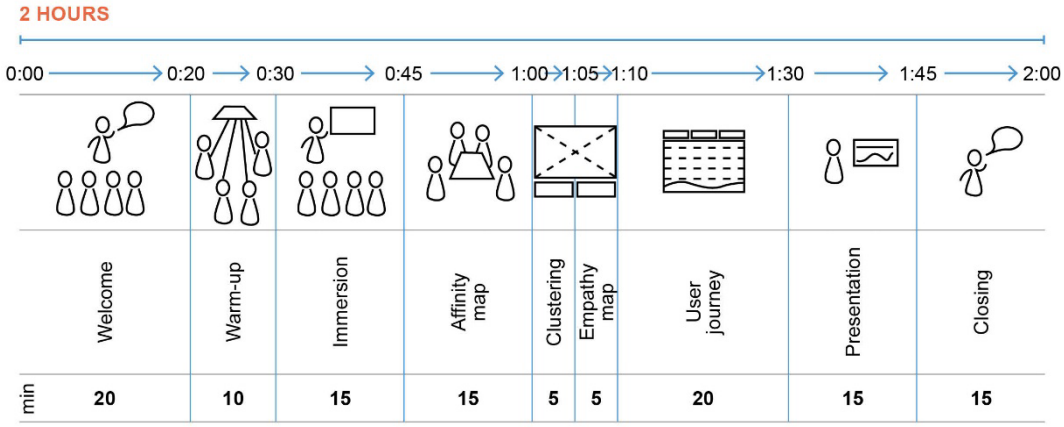


Table 10 - Summary of activities and the duration of each activity in minutes.

The final exercise was to assemble the user journey, dividing it into pre-, during, and post-trip phases, with an additional layer for opportunities to address challenges. Ultimately, each group presented its journey and proposed solutions to the other workshop participants. These presentations sparked discussions to delve deeper into the main findings and insights from the session.

We conducted a post-workshop questionnaire to evaluate the participants' experiences. An online survey was used in the first workshop, while the second employed printed forms answered anonymously at the end of the event, taking 10 to 15 minutes to complete (Appendix M). The initial question assessed participants' prior experience in co-design workshops, gauging their familiarity with participatory processes.

The questionnaire had statements with a Likert scale ranging from 1 (disagree) to 5 (agree). Scores above three indicated a positive response, below were considered negative, and "three" was neutral. The statements were related to the initial presentation with data storytelling, the interactive graphics, the proposal for making the data tangible, the co-analysis dynamics, and the originality of the workshop (Table 11).

Multiple statements on the same topic have been created to triangulate responses. Positive and negative statements were interspersed to prevent bias, balancing agreement and disagreement. People are more likely to agree with a statement than disagree with it (Sauro and R. Lewis, 2012). We averaged responses to similar statements for analysis to gauge participants' overall reactions. In cases where the statement was negative, we reversed the scale by subtracting each value from 6 (Tullis and Albert, 2013).

TOPICS	**STATEMENTS**	**TONE**
Data Storytelling	The presentation helped me contextualize the information.	Positive
Data Storytelling	I am satisfied with the visual support I received regarding the data.	Positive
Data Storytelling	I thought the data was confusing to understand.	Negative
Interactive Dataviz	I initially made an effort to learn how to interact with the data, but then I understood how it worked.	Positive
Interactive Dataviz	I thought the data easy to interact.	Positive
Interactive Dataviz	I would like to receive the data before the workshop.	Negative
Tangible Data	The initial dynamics about my journey (with colorful strings) helped me identify with the topic.	Positive
Tangible Data	The Lego bricks helped me make information tangible.	Positive
Co-analysis Dynamics	I am satisfied with the amount of time to complete the journey.	Positive
Co-analysis Dynamics	I thought the dynamics interesting.	Positive
Co-analysis Dynamics	I found it tiring and sometimes I felt unwilling.	Negative
Originality	I already knew similar dynamics using data visualizations.	Negative
Originality	I thought innovative using data visualization in a participatory process.	Positive

Table 11 – Statements grouped by topics and tone.

6.2.
Analysis and discussion about the participative process

The workshop focused on testing accessible activities using mixed data, with a design process as a helpful element in translating this information into a participant-friendly narrative. In reflection of the workshop sessions and the outcomes achieved through the employed instruments and methodologies, several critical observations can be made.

In the first workshop, most participants traveled by car. During the warm-up activity, they were instructed to position themselves in the room according to the region they came from and extend a string corresponding to the color of the transportation they used. This dynamic led to a tangible visual representation of congestion caused by individual mass transportation, as the strings became entangled—an unintentional yet powerful metaphor.

The amalgamation of participants from diverse regions and transportation modes during group activities proved beneficial, bringing forth varied perspectives and generating new questions that enriched the analysis. The analysis process began by initially searching for patterns in the quantitative data. Subsequently, participants explored online sources to understand the events or factors that could justify observed changes. They examined Twitter comments to comprehend the issues raised and then delved into the diary entries to gain insights into how the user behaved and thought. While technology usage empowered participants to conduct additional research, distractions and varying levels of engagement were noted, with some members occasionally diverging into individual tasks.

The printed graphs on paper boards facilitated annotation, allowing participants to highlight key points (Figure 46). Despite the vast amount of data, the allotted time for the initial analysis proved to be suitable. Participants were able to generate numerous relevant Post-its with insights solely from the first analysis. In subsequent activities, they were also encouraged to add more Post-its if they felt the need. Affinity and empathy mapping activities successfully synthesized data, creating user profiles that formed the foundation for subsequent user journey development. In the end, both workshops resulted in a total of 290 informational Post-its, sometimes containing multiple topics on each piece of paper.

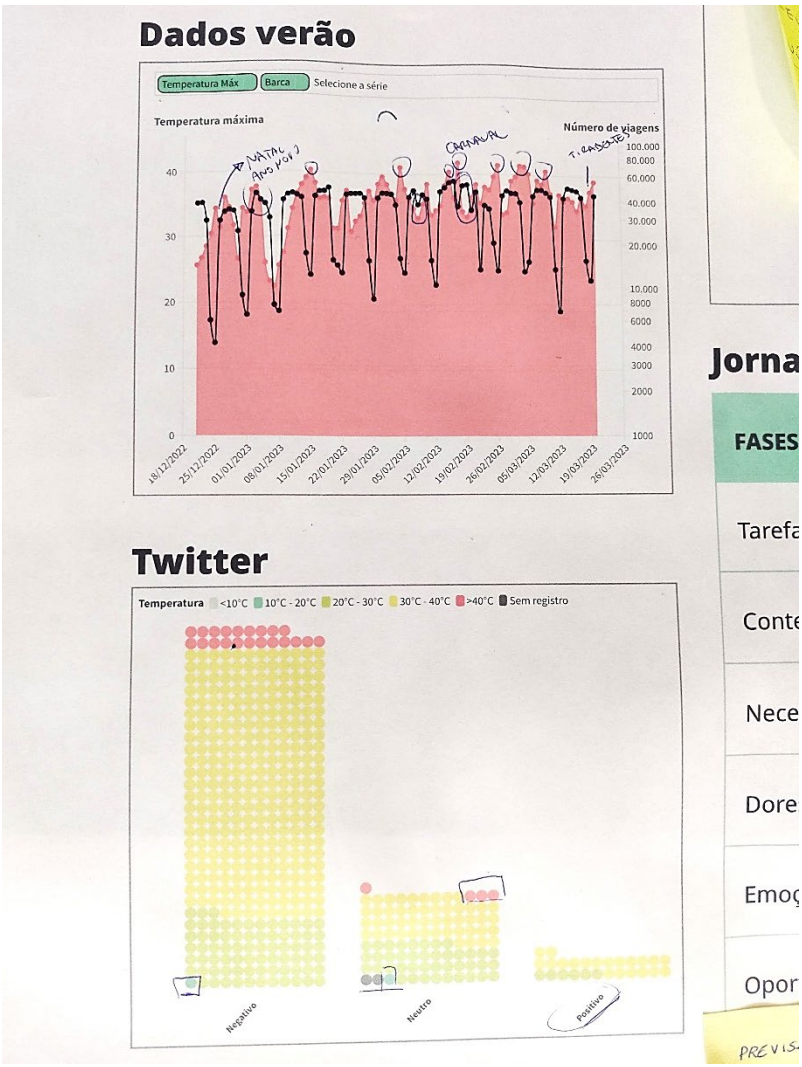


Figure 46 – Printed graphs with annotations from the participants

However, certain issues arose, such as the misplacement of Lego pieces, hindering their association with other data. Participants occasionally sought clarification from the facilitator regarding the meaning of these elements. Additionally, logistical challenges emerged, with participants opting to write directly on the board instead of moving corresponding Post-it notes due to size constraints.

One group went beyond using Post-its solely for written observations and incorporated drawings to illustrate certain points. For instance, they included sad faces at critical points or sketched a map of the city depicting the route of the journey described in the diary (Figure 47).

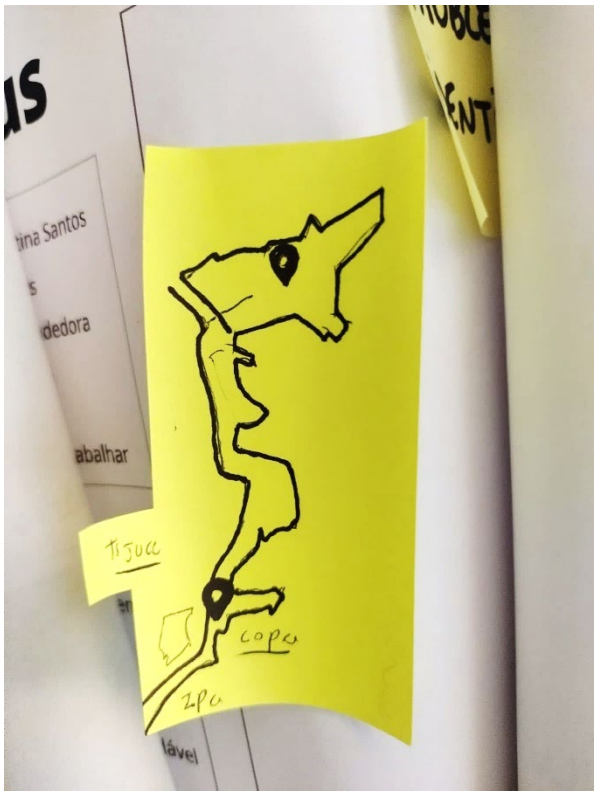


Figure 47 - Map with a route from diary

The final presentation served as a crucial step, providing a platform to synthesize all the knowledge generated by each group. Additionally, individuals from other groups who did not analyze that particular mode of transportation also participated in the discussion, bringing forth different perspectives and suggestions.

Towards the end of the workshop, numerous participants approached us to inquire about the techniques and tools employed for data visualization storytelling. Given that they were all designers, there was a strong interest in replicating these methods within their professional environments, showcasing the potential impact of the introduced methodology within the field of design.

In total, we received 25 responses to the post-workshop questionnaire. When we asked participants to evaluate the initial presentation, which featured a data-driven narrative, the overall score was positive, averaging 4.25 on the Likert scale. Participants with previous workshop experience found the data presentation somewhat confusing, and they expressed slightly less satisfaction with the visual support. However, due to the confidence interval, the results are statistically similar for both groups, and definitive conclusions cannot be drawn in this regard. (Chart 15).

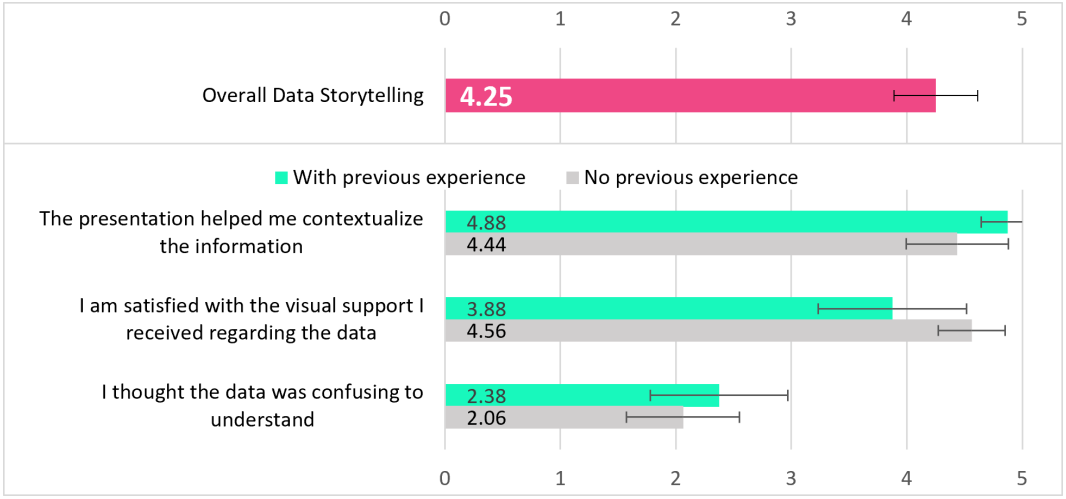


Chart 15 – Data storytelling: The overall score, calculated as the average of related statements, appears at the top. Below, we break down individual statements for participants with prior workshop experience (n=25)

We then inquired about the interactive data made available for analysis. In this regard, the participants provided a slightly lower score, with an average of 3.83 (Chart 16), still in the positive range but including some neutral responses. Several factors can explain this outcome. Firstly, we developed the visualizations using a platform with predefined templates, which occasionally limited the possible customization level, potentially impacting usability (Marques *et al.*, 2022). Additionally, some visualizations presented large datasets, resulting in longer loading times, which may have affected the user experience. Furthermore, participants were often unfamiliar with the computers provided by the university, which added to the usability challenges. Notably, in the final open-ended question, some participants suggested that they could have been asked to bring their computers, allowing them to be more comfortable and proficient with the interaction process from the start.

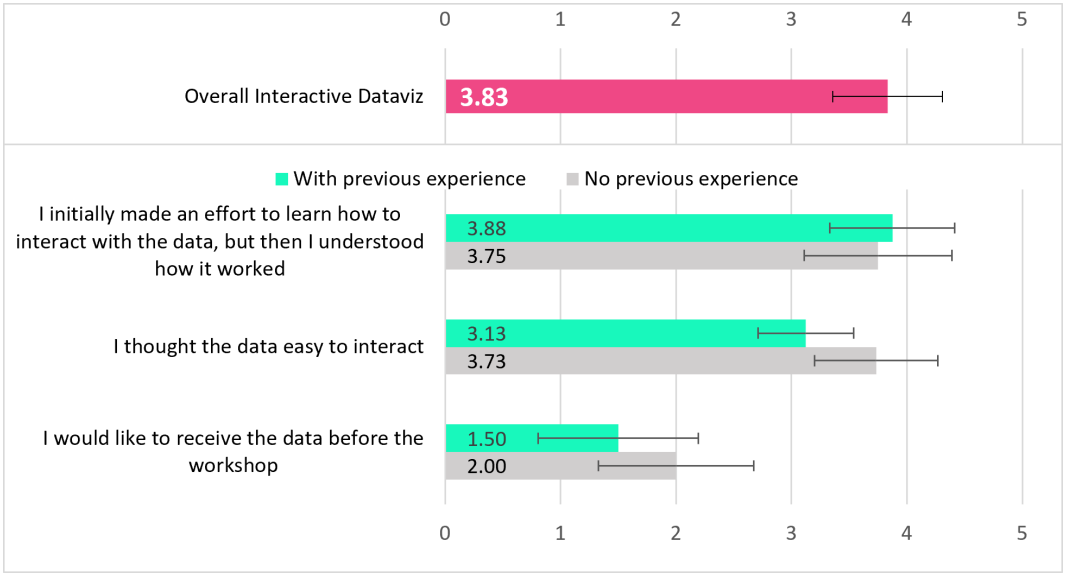


Chart 16 – Interactive Data Visualization: Displays the overall score average and each statement, categorized by participants' experience. We reversed the final statement to reflect the overall score calculation (n=25)

The subsequent two questions focused on the techniques employed to make data tangible. The average score here was even lower at 3.77, with the Lego brick data visualization (Chart 17) being the primary contributor to this result. The initial activity that introduced participants to the concept by utilizing the physical space, strings, and their bodies to visualize data was generally well-received. However, using Lego bricks did not appear to aid in data visualization effectively, and it received a neutral response from participants with prior workshop experience.

The limitations of the Lego-based approach were primarily due to time constraints and resource availability. The simplicity and detachment of the Lego visualization from the other data representations were the main reasons behind this. A more sophisticated approach involving the integration of sensors with raw data, as observed in other research (Baeza *et al.*, 2021), could yield more effective results. This approach would provide a deeper connection between small-scale and large-scale data visualization.

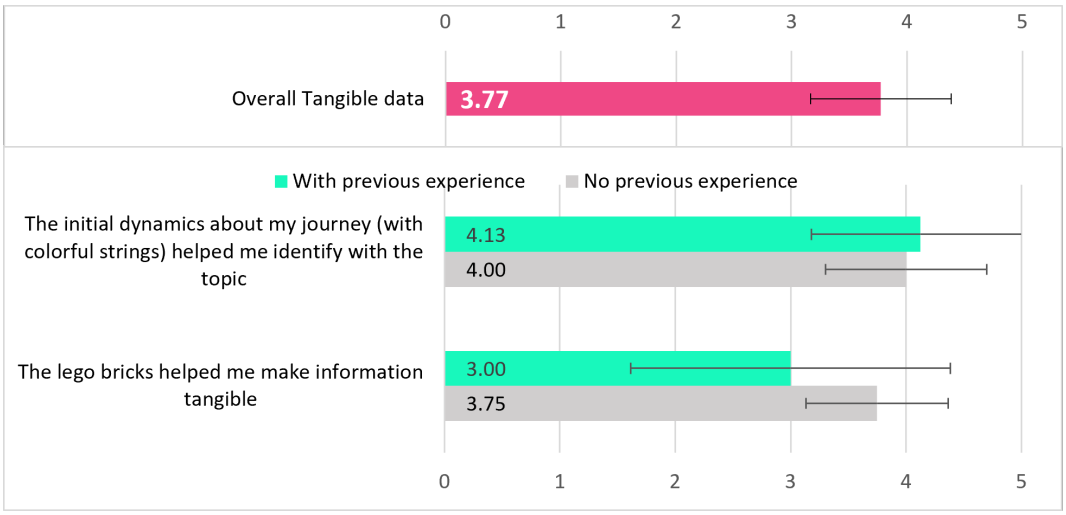


Chart 17 – Tangible data: Feedback on materializing data through specific activities: the warm-up and Lego bricks (n=25)

Participants generally expressed high satisfaction with the co-analysis dynamics, reflected in a positive score of 4.49 (Chart 18). Participants with no prior workshop experience demonstrated higher satisfaction with the time allocated for developing the journey. We can attribute this observation to most of the participants attending the second workshop, where we extended the journey time based on feedback from some participants from the first workshop. Regarding the statement concerning the experience being tiring and inducing lethargy, there were more negative responses from participants in the second workshop, possibly influenced by the earlier timing of the session (7 a.m.). However, it's important to acknowledge that this observation might not capture the full picture, as analyzing data can be quite fatiguing, and more questions about the motivation behind the responses would be needed for more conclusive findings.

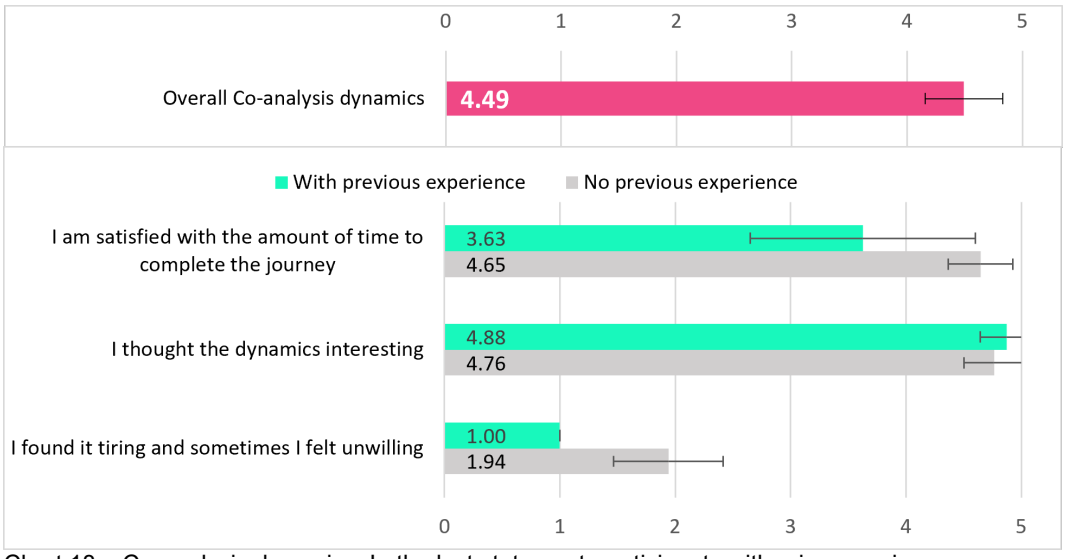


Chart 18 – Co-analysis dynamics: In the last statement, participants with prior experience unanimously provided the same rating, resulting in a minimal margin of error (n=25)

The question regarding the originality of the workshop garnered a positive response, indicated by an overall score of 4.24 (Chart 19). Notably, participants with prior experience with other workshop formats, and thus were more familiar with alternative methodologies, found data visualization in participatory processes particularly innovative. This observation highlights the potential of such techniques to engage and captivate participants with diverse backgrounds and experiences.

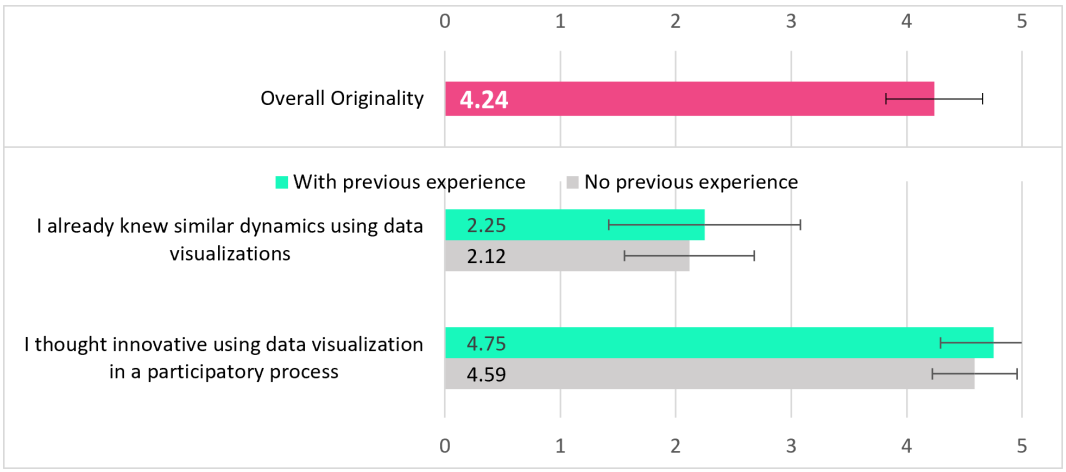


Chart 19 – Originality: Surprisingly, even among those without prior experience, some participants acknowledged similarities to previously encountered dynamics (n=25)

Towards the end of the survey, we queried participants about the rating they would give to their overall workshop experience, based on a scale from one to ten, where one represented a poor experience and ten an excellent one. The average

score was 9, indicating a highly positive evaluation (Chart 20). We did not observe a significant difference when we further segmented the data to compare participants with prior workshop experience against those engaging in such an experience for the first time. Participants with prior workshop experience tended to be more critical, with an average rating of 8.63, in contrast to the slightly higher score of 9.18 among first-timers. However, with the confidence interval, both groups still provided commendable evaluations, with the average rating considered high overall.

Chart 20 – Overall experience: Ratings for the overall workshop experience, using a scale from 1 to 10, where 1 represents a negative rating, and 10 denotes an excellent evaluation (n=25)

We concluded the survey by inviting participants to provide optional feedback through an open question regarding suggestions for improving the workshop. Several insightful suggestions emerged.

One request was for data to be sent before the workshop. However, we asked about it, and most participants did not find it practical. This challenge had been highlighted in previous interviews explained in Chapter 4.2, and the participants often lacked time to review the data in advance.

Another suggestion was to offer access to raw data alongside the visualizations to mitigate the bias inherent to pre-analyzed visual representations. Interestingly, participants occasionally needed to delve deeper into specific aspects, initiating new research based on questions that arose during their initial data explorations. For instance, they would investigate behavior patterns on certain days and then explore external sources like transport companies' websites to understand factors that might influence such patterns. They also used various keyword searches on Twitter to seek answers to their new inquiries. Therefore, initially, the data

served as a catalyst, allowing participants to enrich the analysis with additional information and their unique perspectives.

Participants expressed a desire for more time to create personas. This issue led to some confusion because the users from the Diary Study were predefined and not treated as personas. Therefore, participants wondered if they should strictly analyze data related to these specific users or if they could extend their analysis to include other sources of data from different studies. Designing an additional activity for identifyng personas in a more extended workshop might be beneficial.

One participant mentioned they needed to hear explanations more than once to comprehend the complex subject. However, they could perform the activities successfully once they grasped the concepts. This initial challenge underscored the role of design as a storyteller in such workshops (Design Council, 2021).

In summary, the feedback was predominantly positive, aligning with the high ratings assigned in the previous statements. One comment encapsulated the workshop's overarching objective: "I found everything very intuitive and fun to execute." Indeed, the workshop aimed to deliver data in an intuitive, accessible manner through engaging activities, leading all groups to create journeys, identify challenges, and generate ideas for enhancing the urban mobility experience.

6.3. Insights of mobility experience

The results demonstrate the effectiveness of collaborative approaches for urban challenges and provide deeper insights into urban mobility patterns. However, an examination of the artifacts generated during the workshop reveals both strengths and potential shortcomings in utilizing mixed data to analyze user actions, context, needs, pains, and opportunities. This critical analysis clarifies the credibility of the presented thesis.

Firstly, the quantitative data on the number of trips proved to be insufficient in providing comprehensive insights into mobility behavior, as it appeared disconnected from weather conditions. Consequently, participants leaned more heavily on the qualitative data extracted from diaries and Twitter comments to construct nuanced user journeys. At times, participants would navigate to other websites to delve deeper into specific issues. For instance, a participant in the diary reported issues with a bus route, and workshop participants used the computer to

search for the route and comprehend that citizen's journey.

However, challenges surfaced, particularly in modes of transportation with fewer diary-recorded trips, leading to a heavier reliance on Twitter data. This approach, while valuable, introduces potential bias due to the niche audience on Twitter.

As a result of the workshop, we created individual journey maps for each mode of transportation. Since there were two separate workshops, two distinct sets of journey maps were generated for each mode. Later, we consolidated these two sets into a unified representation to showcase the key findings derived from the participants (Appendix N).

In the bus group, they realized that the weather does not directly impact the satisfaction of the journey, but rather the conditions of the buses. Upon reading the comments, they noticed that the issue lies in congestion, which is more prominent on rainy days, and the lack of air conditioning on hot days, affecting overall satisfaction. They emphasized that positive comments were often linked to the pleasant surprise of the bus operating smoothly without issues. Additionally, a participant from another group raised the relevance of the research to spark a broader discussion on additional factors influencing travel satisfaction, such as dedicated lanes, bus stops, city infrastructure, and governance.

Quantitative data indicated buses as the most widely used mode of transportation, primarily due to affordability and extensive coverage. However, diary responses and Twitter comments revealed a generally poor travel experience, with main complaints related to security concerns, unpredictable bus schedules, and lack of air conditioning.

The journey (Figure 48) highlighted issues related to cost-benefit, waiting time, and discomfort, emphasizing the heat at bus stops and inside buses due to the lack of air conditioning. Participants also highlighted incidents of bus route changes due to shootings, unfortunately, is a reality in Rio de Janeiro. On a positive note, socializing with friends during the trip was mentioned. Co-created solutions for improvement included installing climate-controlled bus stops, larger vehicles with more doors, an increased fleet on hot days, providing information at bus stops with status indicators, displaying available seats outside buses, and implementing a post-trip evaluation system.

Figure 48 – Consolidated journey of Valentina traveling by bus.

Bicycles received more positive comments than other modes of transportation. The diary study confirmed this positive sentiment, with participants expressing satisfaction with their trips. Weather conditions influenced bicycle usage, with a decrease in trips on rainy days.

The quantitative analysis revealed a correlation between milder temperatures and reduced bicycle usage. In response, the participants sought additional information about that period from other data sources and discovered it was a rainy season in the city. Interestingly, as the group presented this issue, a participant from another group proposed the idea of providing and developing equipment such as helmets and raincoats specifically designed for these conditions. This illustrates how collective brainstorming led to the emergence of innovative ideas.

The bicycle journey (Figure 49) highlighted leisure usage with scenic routes, as many respondents used cycle paths in wealthier regions of the city. Disadvantages included the unavailability of shared bicycles, being caught in the rain, and arriving sweaty and disheveled at the destination post-trip. The heat was also a deterrent for choosing bicycles, and participants desired more trees and shade in the city. Opportunities for improvement included increasing maintenance frequency and cycle paths.

Figure 49 – Consolidated journey of Pedro cycling.

Combining data from both the diary and Twitter proved valuable as it allowed for the analysis of a user's behavior over an extended period. If only Twitter had been analyzed, the focus might have been on specific comments or a collective expression of complaints on a problematic day. However, examining the diary revealed how the same participant behaved in various situations, changing modes of transportation and regions within the city. This comprehensive approach provided a big picture of mobility behavior.

For instance, the group analyzing the ferry commented about the diary profile they were investigating, suggesting it belonged to an older man. Consequently, they speculated that many people likely offered him a seat, contributing to his satisfaction with the journey. However, when they examined Twitter, which represents a broader population, they found numerous complaints about heat and dissatisfaction with overcrowding.

Quantitative open transport data and Twitter contributed to understanding patterns and issues related to a specific mode of transportation. In contrast, the diary delved deeper into an individual's behavior, not only within that mode of transportation but also in various circumstances, often involving multimodal journeys. Ferries were typically part of a multi-modal journey, requiring passengers

to access and leave the terminal using other transportation. Additionally, thermal comfort needed improvement, with complaints of heat and non-functioning air conditioning, despite the refreshing sea breeze.

The ferry journey (Figure 50) revealed that traffic on the bridge, making bus or car travel slower, was a determinant for choosing this mode of transportation. The journey was considered positive, with a comfortable environment. Improvement opportunities included protection from rain, sun, and wind at both the boarding and disembarkation terminals and on the ferry itself. Complaints included rough seas during heavy rain and wind, resulting in passengers getting wet. Boarding and disembarking were reported as confusing and lacking organization in queues, suggesting the need for more boarding points. Additionally, all ferries should have air conditioning and synchronize with other modes of transportation for a seamless post-disembarkation journey.

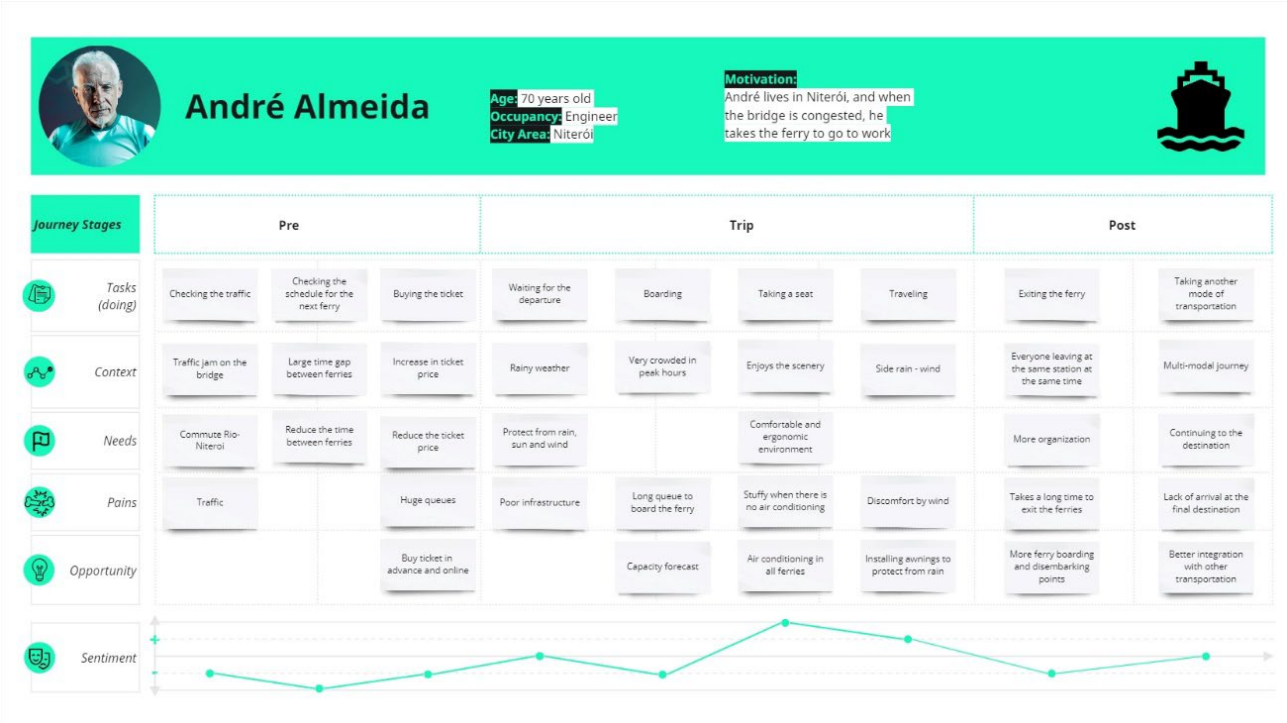


Figure 50 – Consolidated journey of André commuting by ferry.

The metro generally received positive feedback for its climate-controlled environment, predictability, and punctuality. However, like the ferry, passengers may require additional transportation to reach the metro station from their residence or their destination after disembarking. Therefore, knowing which train carriages

have more space could benefit passengers.

The metro group raised a question regarding the efficiency of the internet signal. When examining Twitter data, there might be outdated comments that do not align with current technology. One participant shared her experience from years ago, unsure if it still held. However, upon presenting it to the other groups, they commented that this issue seemed to be an old problem. It revealed concerns about outdated comments, emphasizing the importance of considering temporal relevance in social media platforms.

The metro journey (Figure 51) emphasized the choice of this transportation mode for reasons of security and proximity to the station. However, users encountered challenges such as heat in stations without efficient air conditioning, broken escalators, and infrastructure-related issues. Throughout the journey, participants expressed the need for location awareness due to being underground, the absence of a view, limited internet access, crowded peak hours, occasional discomfort with overly cold air conditioning, and post-trip issues related to unclear station signage. Improvement suggestions included planning apps providing weather, schedule, route, and line information, citywide totems indicating carriage occupancy, and enhanced signage in stations.

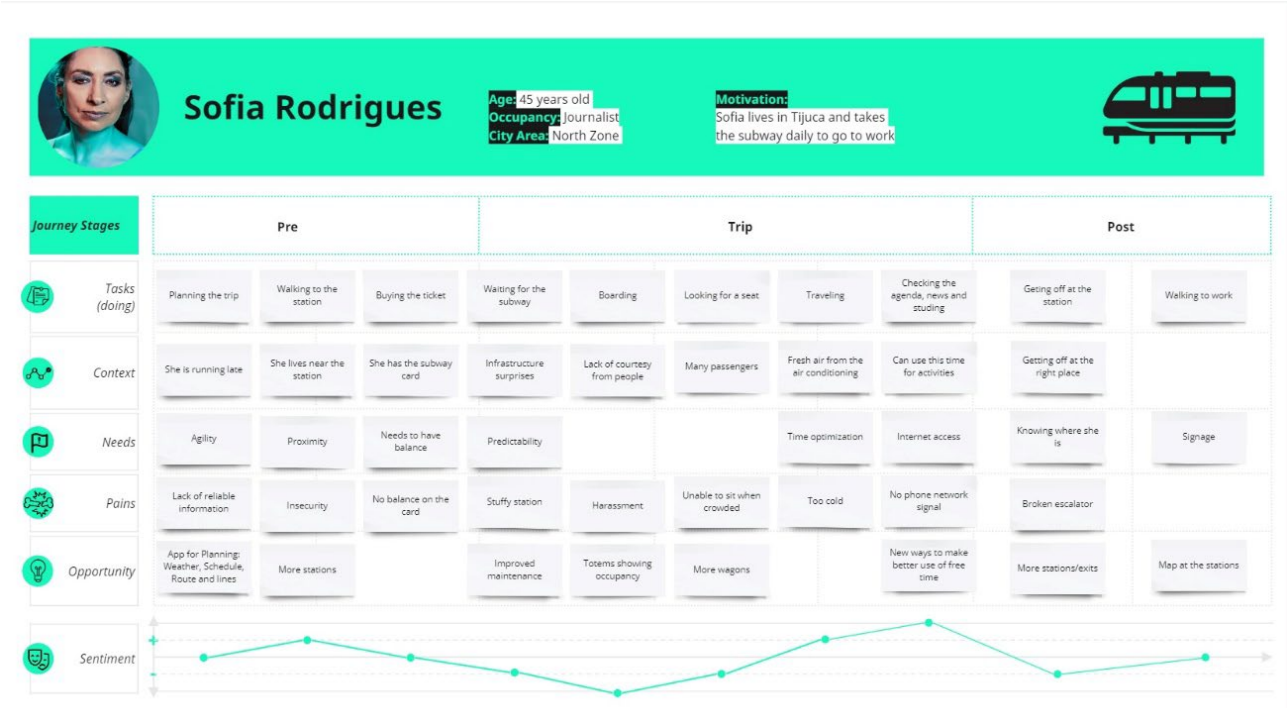


Figure 51 – Consolidated journey of Sofia traveling by metro.

Beyond the collaborative analysis conducted in the workshop, we also employed an artificial intelligence tool embedded in Notion to distill and summarize the comments made by participants in their diaries. The following are notable patterns identified from the text provided:

- **Delays:** Various instances of delays in public transportation, including buses and the metro.
- **Transportation Conditions:** Wide variations in transportation conditions, with some modes (like the tram) considered excellent and others (such as non-air-conditioned buses) deemed uncomfortable.
- **Weather:** Weather, especially heat, influenced mode choice and user experience. Some individuals opted to walk to enjoy shade, while others chose air-conditioned transport.
- **Sidewalks:** Many participants noted sidewalk quality while walking, with some considering them dangerous due to holes and uneven surfaces.
- **Lost Cell Phone:** Unfortunately, one person had their phone stolen during public transportation.
- **Conversations:** Some individuals engaged in conversations with fellow passengers during their journey.
- **Traffic:** Numerous reports of heavy traffic, including jams and delays.
- **Faster Travel:** Some participants mentioned choosing faster modes, like the tram and metro, to avoid traffic and reach their destination more quickly.

Although the journeys provided a structured representation of diary data, the automatic AI analysis brought forth some elements that participants had not explicitly emphasized, thereby enriching our perspective. The AI-generated summary took less than one minute and managed to consolidate a vast amount of data, uncovering semantic patterns. While this represents an initial step in the analysis, relying on this approach may yield superficial insights if it is the sole method employed. The AI analysis focused primarily on textual data and did not extend to identifying patterns in other data types. In contrast, the workshop facilitated the examination of diverse data sources from different perspectives. Each participant brought their life experiences, thereby reducing the risk of bias and enriching the analysis.

Despite the workshop's focus on analyzing the relationship between transportation and weather, many comments and suggestions were related to general mobility issues not directly linked to weather. A risk in participatory processes is the potential lack of clarity regarding the objectives, leading to outcomes diverging from the intended goals. Steen, Manschot and Koning (2011) suggest that those involved in co-design may fail to precisely articulate the specific benefits they aim to achieve, resulting in a mismatch between the benefits of co-design and project goals. This misalignment poses a risk of producing fewer benefits than achievable if the participants had more precisely defined their goals.

Addressing the question of which mode of transportation provided the best experience during hot days in Rio de Janeiro, the subway received positive evaluations for its temperature control, security, and travel time predictability. Bicycles also garnered favorable reviews, associated with moments of pleasure and enjoyment. Paradoxically, on hotter days, people tended to prefer traveling by car to minimize physical exertion and sweating, choosing a mode of transportation that is more polluting and has a greater impact on climate change.

As Eichhorst (2009) outlines, the climatic impacts on transport can be categorized into three aspects: impacts on transport infrastructure, impacts on vehicles, and impacts on mobility behavior. The diary study responses reflected these impacts:

- **Infrastructure:** Following a storm, a participant faced difficulties walking in her neighborhood due to broken traffic signals, impeding her ability to cross the street.
- **Vehicle:** A participant reported their car undergoing maintenance because the rains flooded the city streets, causing engine trouble.
- **Behavior:** Participants altered their mode of transportation due to excessive heat, as illustrated by one participant's choice to opt for Uber instead of walking to the metro due to the intense heat and fatigue.

Choosing sustainable transportation modes must be linked to broader political considerations, such as increasing greenery for shade, enhancing integration between transportation modes, and engaging stakeholders to build a unified and unique mobility service experience—an aspect lacking in Rio de Janeiro. As Medeiros (2019) emphasizes, a city's ability to adapt to climate-related impacts is

pivotal for the resilience of its transportation system, intertwining urban planning with climate considerations.

In conclusion, the mixed-data co-design approach showcased its proficiency in generating actionable insights, a feat unattainable through the conventional top-down urban epistemology solely reliant on big data. Participants successfully crafted user journeys from a vast dataset, effectively highlighting pain points and areas for improvement. The workshops brought to light the intricate relationship between climate and urban transport, revealing insights that would remain obscured when solely relying on big data. The quantitative data alone wouldn't capture the nuances involved in mobility behavior as illuminated by Twitter and diary entries. The inclusion of narrative data guided participants to initiate independent explorations.

These workshops not only proposed alternative methods of sharing data but also underscored the participants' heightened comprehension of the data. This is evident in the substantial volume of information downloaded and organized in a logical and understandable format. The data analysis conducted during the workshops resulted in valuable assessments and insights, showcasing an elevated level of data literacy among the participants. It is noteworthy that the majority of participants had no prior experience in participatory processes and dynamics with data visualizations. This co-design methodology proved to be an initial approach to unraveling complex urban challenges, emphasizing the importance of integrating diverse data sources and involving communities in comprehending and addressing these issues.

7.
Discussion

Our overall objective was to test a co-design process using mixed methods to analyze mobility behavior. For this, we divided the methodology into two parts: an exploratory phase, where we identified issues related to other mobility projects involving urban data, technology, and citizen participation, and an explanatory phase, where we tested the collection and analysis of mixed data (Table 12).

In the first stage, we analyzed reports from the Civitas initiative projects and interviewed professionals working in the field. In the Civitas projects, we identified challenges in the areas of big data, citizen engagement, and transparent and accessible communication. Some solutions involved the use of crowdsourcing, social media, artificial intelligence, gamification, data visualization, co-design, and prototyping. Subsequently, we interviewed professionals to delve deeper into issues that had already appeared in the reports, attempting to explore how they tackled these challenges. We discussed making data accessible, utilizing data in participatory processes, lessons learned during the pandemic, and strategies to increase citizen engagement.

Based on the results of this initial phase, we developed three studies for collecting mixed data, specifically focusing on the impact of weather on urban mobility. As revealed in the project analysis, the abundance of available information highlights the need to map existing accessible data—a initial step toward broader information access. Therefore, we initiated an inventory of municipal open data, assessing the usability of the city portal. Challenges in accessing this data, as reported in the explored projects, were identified.

In response to these challenges, we conducted contextual interviews with 15 participants and utilized the SUS questionnaire. We identified numerous usability issues, resulting in a score of 43.75 considered unacceptable. Consequently, we pursued access to the responsible departments with the specific data requirements. Moreover, the data departments of Metrô Rio and TemBici facilitated access to comprehensive datasets. The government's transparency portal also proved effective in providing data from public entities. This underscores the importance of collaborative efforts across various fronts. The ease of collaboration reported by

interviewees working in public sectors with direct contact with data owners aligns with our experience in this case.

TOPICS	PHASE I- PROJECT EXPLORATION	PHASE II – TESTING DATA COLLECTION AND ANALYSIS
Big data	• Data auditing • The public workers have easier access to collect data.	• Difficulties in accessing municipal open data • Pursued direct access to responsible departments, addressing specific data requirements. • Effectiveness of Transparency Portal • Importance of collaborating on multiple sectors
Citizen engagement	• Collaborating with other community initiatives • Taking advantage of neighborhood meetings and events already happening. • Confronting taboo topics.	• Effective collaboration through leveraging existing events reduced recruitment challenges and attracted a diverse sample. • Engaging communication strategies, such as posting impactful data in the diary, encouraged participant discussions.
Institutional Communication	• Transparent communication • Continuous information • Plain language • Channels for distributing information • Avoid participation fatigue	• Shared research updates using transparent and plain language to simplify complex topics. • Utilized Instagram for both diary data collection and participant communication. • Encountered challenges in minimizing participant fatigue, leading to a decline in engagement over the study period.
Crowdsourcing	• Tracking problems • Learning the communities and stakeholders' needs • Source of ideas and opinions • Representative mixes • Social media is rich in crowdsourcing data and could have extensive material for analysis. • Unstructured data, some technical challenges must be overcome to take better advantage of it.	• Twitter featured thousands of voluntarily posted comments, eliminating the need for active participant engagement. • Recognized Twitter as a valuable data source due to its vast and diverse content. • Allowed for a deeper exploration of specific problems. • Identified it as a valuable tool for pinpointing areas that required improvement.
Social media	• Without access barriers • Interactive • Sentiment analysis • Non-structured data • Social media as a source of information. • Sometimes they use it to understand the target audience, but more often, as a tool to communicate with the population.	• Leveraged the platform's widespread usage. • Noted the potential of visual elements to make data more accessible and engaging. • Encountered challenges in analyzing sentiments on Twitter, especially in detecting sarcasm. Noted the prevalence of negativity. • Acknowledged the need for improvement in automated natural language analysis. • Addressed the influence of Twitter's policy and algorithms on the research process.
AI	• Retrieving data from crowdsourcing platforms • Translating information. • Explore using AI to automate data processing and analysis aspects. • Streamline the process, reduce errors, and allow for more efficient use of resources.	• Demonstrated use of AI in extracting and analyzing sentiment data from crowdsourcing. • Acknowledged the role of AI in facilitating the translation of information. Cited instances such as suggesting content, generating posts, creating quizzes, and crafting text. • Noted the beneficial role of AI in generating participant images and names, anonymizing

		diary participants while maintaining identification. • Pointed out that AI-generated summaries consolidated vast amounts of data in less than a minute.
Gamification	• Incentivizing users • Providing feedback and statistics about travel habits • Raising citizen awareness on sustainable mobility • Comparative measures.	• Highlighted the need for a genuine incentive beyond gamification to drive user engagement. • Offered personalized artwork with travel data as the challenge's prize. • Suggested making participant statistics available to boost engagement. • Explored the use of comparative measures to convey information about challenging-to-quantify data.
Data visualization	• Dashboards • Easily understandable formats • Visualizing data in workshops is uncommon; visualization tools are typically used during analysis rather than in the discovery. • User-friendly website offers open data in an informative way, with an editorial context.	• Explored the co-analysis of data using storytelling and visualization techniques in the discovery process. • Many workshop participants expressed curiosity and interest in replicating the visualizations. • Positive Evaluation Scores • Limitations in creating personalized visualizations for the narrative. • Selected Flourish software for efficiency and pre-defined templates, streamlining development without programming. • Proposed exploring other platforms, like Processing, for their customization potential, albeit requiring programming knowledge.
Co-design	• Co-design workshops • A questionnaire to measure impact • Journey diary • Send data before the meeting to prepare the participants. • Miro tool for online meetings • Create immersive narratives to guide through the boards. • Complementing online sessions with in-person meetings: one at the start for introductions and engagement, and one at the end for closure and celebration.	• Utilized methods such as questionnaires and journey diaries as effective tools for measuring impact and gathering citizen data. • The diary unveiled diverse participant behaviors, facilitating journey creation. • Employed questionnaires at the end of each method to assess the impact of each approach, capturing intangible data such as quality and innovativeness. • Most participants did not find it practical to send data beforehand for better preparation. • Used Miro for crafting narratives, showing adaptability for virtual versions in the pilot.
Prototyping	• Building a stronger collective memory. • The Future City Game is a collaborative process that utilizes data materialization.	• Attempted Lego visualization for small diary data in the workshop. • Faced challenges, including misplacement of Lego pieces and neutral responses in the questionnaire. • Limitations due to time and resources. Future improvements may enhance integration with technologies.

Table 12 – summary of study results

We implemented a diary study on Instagram, utilizing gamification techniques, data visualization, and transparent communication. Key findings from the research revealed the potential of social media as a data collection tool. As a widely used platform, people are accustomed to sharing information through it,

benefiting from its visual resources to enhance engagement. However, the impact of gamification in the diary study was limited. As stated by an interviewee in Chapter 4.2, gamification alone does not motivate people to use it; there must be a real incentive.

A concept that emerged as an idea for gamification involved using statistics related to travel habits. The challenge's prize was a personalized artwork showcasing the winner's travel data. However, a participant suggested making these data available during the study to encourage participants to track their habits and enhance transparency. Since the statistics were only provided at the end, participants were uncertain about the value of their efforts.

Furthermore, the study suggested that a more extensive project with greater resources could explore more engaging gamification strategies. Collaborations between the municipality and private enterprises could provide practical solutions based on identified needs. Future research could delve deeper into gamification and establish partnerships to address these issues more practically.

The project analysis highlighted the use of comparative measures to convey information about data that is challenging to quantify. Therefore, in Figure 52, examples of posts comparing the impact of congestion in Rio de Janeiro are presented. Another strategy observed in the projects was employing controversial topics to engage the population. In the diary, we posted about various subjects, including impactful data (see examples in Figure 53).

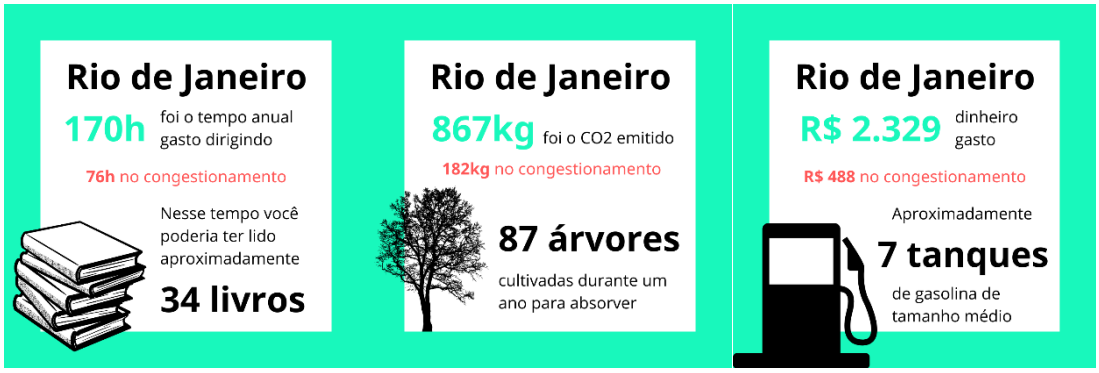


Figure 52 - 170 hours annually driving could have been spent reading 34 books, emitting 867kg of CO2 would require planting 87 trees for absorption, and spending R$ 2329 equals the cost of 7 gas tanks

Figure 53 - 92% of transport consumption from petroleum, Days above 40°C in the city. 95% of the city exposed to heatwaves.

The third data collection technique involved extracting data from Twitter using natural language processing to analyze text sentiment. We searched for hashtags related to transportation in Rio de Janeiro and crossed them with the weather-related keywords, mentioned in the diary. As observed in the project outcomes, social media stands out as a rich reservoir of crowdsourced data and emerges as a source for generating ideas, opinions, and representative mixes. This method proved highly relevant because, unlike the diary that required active engagement from participants, Twitter already had thousands of voluntarily posted comments. It is a rich material that can be explored using different searches to delve deeper into specific topics.

Sentiment analysis did not prove very useful for measuring the number of positive or negative comments, as the majority were negative, and many positive comments were sarcastic. However, it was useful for filtering the most negative comments and identifying potential problems for improvement. Automated natural language analysis still needs improvement to detect nuances of slang and sarcasm. Nevertheless, the field of generative AI is evolving rapidly, and advancements are expected soon. Like Instagram, Twitter is subject to changes in the company's policy and algorithms, which influenced the research.

Finally, after exploring these three data collection methods, we tested co-analysis in a participatory workshop. The goal was to use storytelling and data visualization techniques to make mixed data more accessible. As discussed by Meroni and Sangiorgi (2011), the design process plays a role in facilitating dialogues with different stakeholders. In addition, Mulder (2018) suggests that involving citizens from the initial stages of problem identification fosters a sense of

ownership in the proposed solutions and guarantees a sustainable, long-term engagement in the project. Our workshop was created to assist designers in translating data into accessible tools, allowing participants to work freely and explore the problem in greater depth.

As Oliveira and Campolargo (2015) conceptualized the term "human smart city," it should not focus solely on technologies. Despite the advancements in data collection, such as obtaining more travel data and analyzing large volumes of social media data through natural language processing, citizen participation remains essential for a city to be both human-centered and intelligent. In our study, citizens reported their needs in the diary study and co-created solutions during the workshop, adding richness to the analyzed scenario.

As a solution found in the projects, we utilized the Miro platform to craft immersive narratives, guiding participants through interactive boards and transforming the experience into virtual environments. Although we didn't conduct virtual workshops, we leveraged this platform for in-person presentations. It proved useful as it had workshop tools such as a timer and music, and could easily be adapted for a virtual version, as demonstrated in the pilot. The presentation successfully synthesized a large volume of data into a visual narrative.

The projects also suggested sending data to participants beforehand for better preparation. When we inquired about this, most participants did not find it practical. Despite this, there was one request for data to be sent before the workshop, highlighting a challenge previously identified in interviews where participants often lacked time to review the data in advance.

Co-analyzing mixed data in innovative workshops has the potential to address urban challenges in smart cities. Combining quantitative and qualitative data with data visualization and storytelling enhances our understanding of urban mobility patterns. As Lupton (2017) emphasized, design is storytelling, and in our process we use design to tell stories from data. By harnessing data-driven design, cities can enhance urban mobility and residents' quality of life.

As observed in the projects of the first phase, results indicated transparency, continuous information flow, and a direct channel for improving institutional communication. We utilized Instagram not only for diary data collection but also as a communication platform with the participants. We posted updates about the research (see Figure 54) using simple language for complex topics.

Figure 54 - Images posted halfway through the study with summarized numbers of recorded trips.

However, since the diary method is time-consuming, it was challenging to minimize participant fatigue. As indicated in some participants' feedback and the decrease in engagement, the first week had an average of 10 entries per day, while the last week saw a decline to 3.6 entries (Table 13). We did not identify a clear correlation between posts and entries; generally, entries were fewer on weekends and higher during weekdays, in line with expectations related to work-related activity.

WEEK	TOTAL	PER DAY
27/02/2023 - 05/03/2023	50	10
06/03/2023 - 12/03/2023	68	9,7
13/03/2023 - 19/03/2023	53	7,5
20/03/2023 - 26/03/2023	51	7,2
27/03/2023 - 02/03/2023	18	3,6

Table 13 - Number of recorded trips in the diary.

As evident from the project outcomes, AI can be utilized to extract and analyze data from crowdsourcing platforms, as demonstrated in the sentiment analysis of Twitter. Moreover, it aids in facilitating information translation. In the diary, AI played a pivotal role throughout the process by suggesting content, generating posts, creating quizzes, and crafting text. AI was also beneficial in generating participant images and names, contributing to anonymizing diary participants while maintaining identification. While the structured representation of user journeys provided valuable insights, the automatic AI analysis revealed

elements that participants hadn't explicitly emphasized, thereby enhancing our perspective. The AI-generated summary, completed in less than one minute, effectively consolidated a vast amount of data, exposing semantic patterns.

Regarding the climate crisis, the study found that people in Rio de Janeiro are affected by weather conditions when it comes to their satisfaction with city commutes. However, it does not lead them to change transportation modes based on the weather, as indicated by the quantitative data, suggesting no significant correlation between transportation modes and climate conditions. Buses received criticism for being unsuitable in extreme temperatures. The research also highlighted inequalities in transportation access, with wealthier individuals having more choices like private cars, Uber, ferries, metro, and bike paths. In contrast, residents in peripheral neighborhoods faced fewer options, high fares compared to their income, and security concerns. This is evident in comments from both the diary and Twitter, reflecting reports of violence along key routes connecting peripheral areas to the city center.

These issues surrounding climate change and urban mobility present several elements that make them complex problems. Wicked problems, as defined by Kotaniemi, Suoheimo, and Miettinen (2023), are unsolvable issues like global warming. Cardoso (2011) argues that complexity implies a system with numerous elements, layers, and structures. In our study, we utilized various data from different sources and natures to be co-analyzed by the participants. As highlighted by the Design Council (2021), addressing the climate crisis is a significant challenge, and design plays a crucial role in bridging the gap between technological research and innovation. Mixed methods attempt to interconnect various elements but do not provide a definitive answer; instead, they offer initial insights for future research to delve into the system's details.

As observed in the projects, methods such as questionnaires and journey diaries serve as tools for measuring impact and gathering citizen data. We utilized the diary to collect information about mobility experiences, revealing how the same participant behaved in various situations, changing modes of transportation and regions within the city. This comprehensive approach provided a big picture of mobility behavior, facilitating the creation of journeys in the workshop. Questionnaires were employed at the end of each method to evaluate the impact of each approach. This served as an attempt to capture intangible data such as quality

and innovativeness, as suggested in the project analysis.

While recognizing the value of participatory design processes, the research acknowledged limitations due to time and resource constraints. It emphasized the need for broader sampling and additional time to explore automating Instagram-based research given the platform's closed nature.

As observed in the exploratory phase, leveraging existing events to conduct collaborative activities proves to be a sound strategy. Given our focus on testing the process with designers, we seized the opportunity to organize the first workshop during an event attended by numerous designers and the second workshop during a university class. This approach offered significant advantages; recruitment challenges were mitigated, as participants were already present at the event location, eliminating the need for additional travel. Additionally, this led to a high sample, fostering substantial contributions.

However, it's important to note that leveraging existing events for recruitment may have a negative impact on inclusivity and diversity, as it excludes individuals who are unable to attend such events. While the workshop involved designers to test the process, future studies should involve diverse stakeholders from the city planning process to further evaluate its effectiveness.

We noted in the initial phase that visualizing data in workshops was unconventional; typically, visualization tools were employed during analysis rather than in the discovery process. Lupi (2017) emphasizes the importance of making data unique, contextual, and relatable as data becomes more prevalent. This motivated us to explore the co-analysis of data, utilizing storytelling and data visualization techniques to enhance the accessibility of mixed data.

Data visualization has become widely used across various fields, from technical and scientific domains to arts, communications, and services (D'Ignazio and Bhargava, 2018). While we encountered intriguing examples of data storytelling tools, they were often underutilized, serving more as art displays than as tools for community exploration. Data storytelling, as described by Dykes (2020), enhances data's accessibility, memorability, and utility by employing narrative and visuals to offer fresh perspectives to audiences.

The study can be deemed successful, considering that many workshop participants expressed curiosity and interest in replicating the visualizations. In the post-research survey, when participants were asked to evaluate the initial

presentation featuring a data-driven narrative, the overall score was positive, averaging 4.25. Similarly, the question regarding the originality of the workshop received a positive response, with an overall score of 4.24. Towards the survey's end, participants were asked to rate their overall workshop experience on a scale from one to ten. The average score was 9, indicating a highly positive evaluation.

Some tools experienced usability issues, such as responding to the Instagram diary via stories and interacting with the computer graphics during the workshop, as well as the Lego pieces. In the case of the diary, we provided a tutorial highlighting the dynamics, but perhaps that alone was not sufficient. Sending an email before starting the study detailing how the data would be collected could have been more helpful.

For the workshop, sending this information beforehand might not have been useful since we didn't know who would participate. However, during the explanation of the dynamics, we could have set aside a few minutes beforehand to explain how each interaction object worked.

The Lego pieces were also not used for analysis, remaining lost on the workshop board. One way to address this would be to integrate the pieces with the data, reflecting physical interaction with a digital interface and providing feedback to the user. The development of technologies that integrate the real world with the virtual, such as the Internet of Things and augmented reality, could provide solutions for co-design tools. The Lego could have sensors that control the data, eliminating the need to use a mouse or screen to interact with the visual interface. Alternatively, an augmented reality headset could provide an additional layer of information when users wear and interact with the physical board. However, as emphasized by Meroni and Selloni (2022), the full potential of these technologies remains unexplored and would require more time for testing and development.

As categorized by Steen, Manschot, and Koning (2011), the design process interacts with users in three ways: "say," "do," and "make". In our study, we listened to what users said through their diary studies, their posts on Twitter, and their verbal contributions during the workshop. We observed what they did through quantitative data on municipal travel behavior and how they self-recorded in the diary. And in the workshop, we engaged in "make" through co-design, where participants collectively analyzed and discussed opportunities and solutions for the identified pain points.

8.
Conclusion

This research focused on citizen-centered design processes within smart cities, aiming to tackle the challenge of underutilizing digital data with qualitative research. The central question explored was how to integrate big data and citizen participation in enhancing a design process, using as an example the theme of smart urban mobility.

Understanding citizens' behavior, especially with the increasing frequency of extreme weather events, aids in the planning of city adaptations to this new reality. Involving citizens and examining various influencing factors can provide insights into mobility patterns in this complex subject. Furthermore, proposing new methods adapted to the current technological landscape may help address the demands of the contemporary world.

To accomplish this, we initiated our exploration by examining the current state of the field, investigating existing research and implementations in smart cities. Our goal was to distill insights from these practices. Subsequently, drawing from these learnings, we conducted a series of studies to test the collection, integration, and analysis of mixed data.

In the initial chapters, we defined theories related to the research theme. We explored the distinctions within the concept of smart cities, emphasizing that it is not solely about technology but also concerns sustainability and citizen well-being, among other factors. This aligns with our perspective on the significance of integrating big data with qualitative citizen data. Additionally, we investigated the relationship between mobility and climate change, delving into how human behavior affects the planet’s sustainability. The theoretical framework emphasized the intricate connection between urban mobility and climate change, highlighting the need for a systemic view to address the complex issue of global warming.

We delved into the topic of urban technology, examining the surge in available data and its potential utilization for urban management. Following urban data discussions, we highlighted the ongoing privacy debate and the MaaS concept.

In Chapter 3, we defined the concepts of citizen-centered design, underscoring why this research took place within the Design department and

highlighting the critical role of the design process in addressing the raised problems. Initially, we outlined the changes in the design field, delving into service design and the role of data and research in this process. We then explored the role of design in social innovation and, more specifically, in solving complex problems. Design plays a crucial role in navigating and facilitating problem-solving strategies in this systemic process that involves numerous variables, factors, stakeholders, and methods—contributing to addressing crises like climate change. Finally, we emphasized the designer as a storyteller, a unique aspect of design compared to other fields dealing with systemic processes. Design possesses the ability to visualize and illustrate complex data in an accessible manner, ensuring that all stakeholders are on the same page and translating complexity into a common language, thereby facilitating dialogue.

The studies presented herein an examples of applying the proposed techniques, which can be readily adapted to diverse scenarios (Figure 55). Here is how this process unfolds and can be tailored for various settings:

1 **Framing the research question:** The initial step involves framing the research question, offering options of exploratory and confirmatory research. In this phase, the preparatory research is crucial as it shapes and formulates the research questions. These questions can stem from various sources such as client briefs, customer complaints, workshops, or other relevant inputs. However, a challenge arises as research questions in design tend to undergo refinement over time, reflecting the iterative and explorative nature inherent in design research. This iterative process ensures that the questions evolve, becoming more refined and targeted as the research progresses.

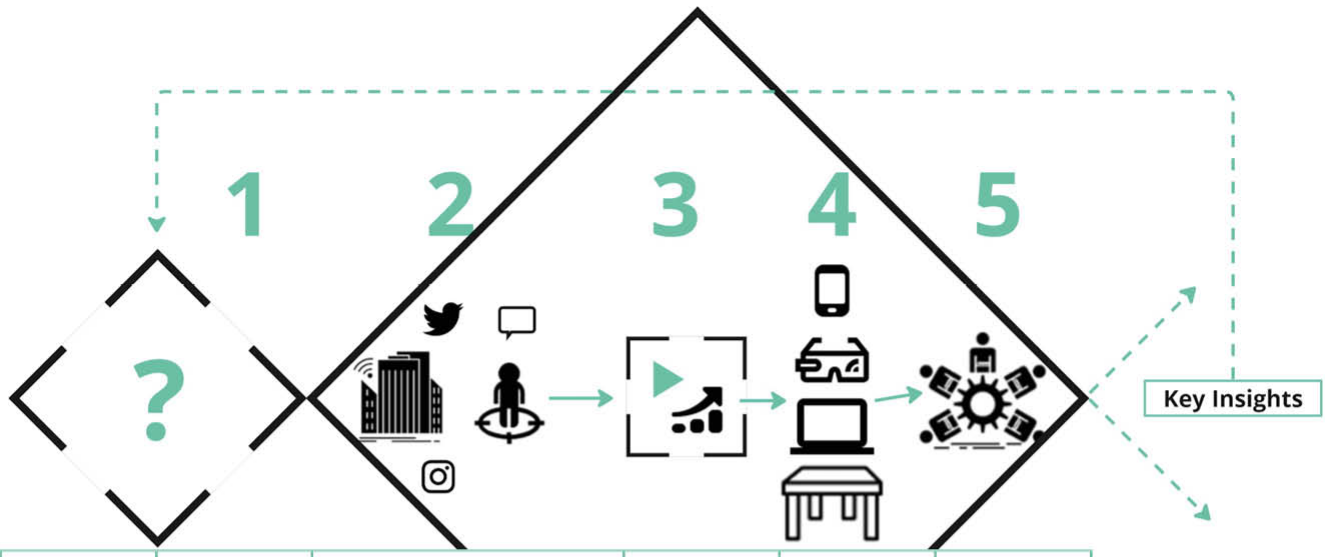
2 **Collection of mixed data:** The second step involves the collection of mixed data, encompassing both quantitative and qualitative approaches. In the quantitative realm, various options such as open data portals, questionnaires, social media, and monitoring devices are available. Opportunities in this phase include mapping the available data, emphasizing the significance of collaborative efforts, and recognizing platforms like Twitter as valuable data sources with vast and diverse content. Additionally, crowdsourcing is highlighted for tracking problems. Challenges in the quantitative domain involve accessing municipal open data and dealing with unstructured data. On the qualitative side, options include interviews, ethnographic studies, diary

studies, and TIPS and TOPS methodologies. Opportunities in qualitative data collection lie in collaboration through leveraging existing events, reducing recruitment challenges, and attracting a diverse sample. Engaging communication strategies, such as posting impactful data, encourage participant discussions. However, challenges in the qualitative realm include addressing participant fatigue and sustaining engagement, emphasizing the need for a genuine incentive to drive engagement.

3 **Crafting a data storytelling:** The third step involves crafting a compelling data storytelling approach, utilizing various options such as video, animation, charts, and textual elements. Opportunities in this phase include leveraging AI to generate participant images and names, ensuring anonymization while maintaining identification. The use of Miro is highlighted for crafting immersive narratives. However, challenges may arise in this step, particularly when using templates, as it could introduce usability issues. On the other hand, fully customizable platforms demand programming skills, adding another layer of complexity to the storytelling process.

4 **Interactive data visualization:** In the fourth step, the focus is on interactive data visualization, exploring options like computers, smartphones, tablets, interactive tables, and virtual or augmented reality. Flourish software is identified as an opportunity for its efficiency and pre-defined templates, while Processing is mentioned for its customization potential, although it requires programming knowledge. The integration of Lego pieces with technologies is proposed as a developmental avenue. However, challenges may arise, particularly when sending data beforehand, as it risks duplication of work and time wastage if the information is not reviewed in advance.

5 **Adaptable co-analysis dynamics:** In the final step of the process, the emphasis is on adaptable co-analysis dynamics, featuring options such as persona creation, affinity mapping, and ideation. Opportunities arise in using physical space for a warm-up to visualize data, implementing concepts, testing or evaluating solutions, building a stronger collective memory, and facilitating group presentations for synthesizing knowledge. Challenges include allocating enough time for each dynamic to analyze extensive data without overwhelming participants. Addressing the inclination to focus on criticism rather than imaginative contributions is also a challenge in this phase.



Steps	1 Framing the Research Question	2 Collection of Mixed Data Quantitative	 Qualitative	3 Crafting a Data Storytelling	4 Interactive Data Visualization	5 Adaptable Co-Analysis Dynamics
Some options	• Exploratory research • Confirmatory research	• Open data portals • Questionnaire • Social media • Monitoring devices	• Interviews • Ethnographic • Diary Study • TIPS and TOPS	• Video • Animation • Charts • Textual elements.	• Computers • Smartphones • Tablets • Interactive tables • Virtual or augmented reality.	• Persona creation • Affinity mapping • Ideation.
Opportunities	• Preparatory research is essential for shaping and formulating research questions, which can originate from a client brief, customer complaints, workshops, or other sources.	• Mapping the available data • Significance of collaborative efforts across various fronts • Recognized Twitter as a valuable data source due to its vast and diverse content. • Crowdsourcing for tracking problems	• Collaboration through leveraging existing events reduced recruitment challenges and attracted a diverse sample • Engaging communication strategies, such as posting impactful data, encouraged participant discussions.	• AI in generating participant images and names, anonymizing them while maintaining identification. • Miro for crafting immersive narratives.	• Flourish software for efficiency and pre-defined templates, • Processing, for their customization potential, albeit requiring programming knowledge. • Develop Lego pieces integration with technologies.	• Warm-up utilizing physical space to visualize data. • Implementing concepts, testing or evaluating the potential of solutions • Building a stronger collective memory • Group presentation to synthesize knowledge
Challenges	• Research questions in design often undergo refinement over time due to the iterative and explorative nature of design research.	• Accessing municipal open data • Unstructured data	• Participant fatigue and sustaining engagement. • Need for a genuine incentive to drive engagement.	• Utilizing templates may have usability issues, while a fully customizable platform demands programming skills.	• Sending data beforehand risks duplication of work and time wastage if the information is not reviewed in advance.	• Allocating sufficient time for each dynamic to analyze a large volume of data without becoming overwhelming • People often want to participate in criticizing but do not see the possibility of imagining

Figure 55 – Proposal for a mixed-data design process

Source: Adapted from the research process of Stickdorn *et al.* (2018).

This approach encourages designers to utilize data-driven narratives for collective problem analysis. It involves engaging diverse stakeholders, such as city service providers, residents, and professionals from the project's inception. This approach can enhance sustainability by leveraging the available data to gain comprehensive insights and work towards more effective solutions for urban challenges. Although participants evaluated the activities in our studies, it remains uncertain if they truly understood the data. Consequently, future studies should prioritize assessing participants' capability to answer questions based on the data.

Nevertheless, due to time constraints and resource limitations, it was not feasible to tailor and create personalized visualizations for the narrative developed in the workshop. We selected the Flourish software due to its efficiency, and integration with pre-defined templates for visual stories, streamlining development without the need for programming. However, it exhibited some usability issues. Other platforms, such as Processing, could be explored in future research for their customization potential, albeit requiring programming knowledge. Subsequent studies may focus on generating more adaptable and compelling visualizations using versatile tools suitable for different data sources.

In the projects of the first phase, we observed the use of prototyping for constructing collective memories, along with examples of data materialization. Therefore, we attempted to employ Lego pieces to visualize the small data from the diary. However, certain challenges surfaced during the workshop, such as the misplacement of Lego pieces, impeding their association with other data, and receiving a neutral response from participants in the questionnaire. Future refinement, potentially incorporating technologies bridging small data with big data, could enhance the integration of Lego visualization.

The projects also underscored the designer's role in transforming abstract ideas into tangible experiences to envision future scenarios. Since our workshop did not encompass the ideation phase, these activities were not tested. However, for future research, considering ideation, prototyping, and testing activities could be worthwhile.

We delved into the examination of existing technologies and conducted experiments with diverse approaches to collect and analyze data. Yet, the scope of design extends beyond merely embracing current technological solutions. It necessitates a vigilant awareness of emerging technologies, coupled with the

flexibility to adjust processes for more effectively meet evolving demands. Given the swift progress in the realm of artificial intelligence, there emerges a significant opportunity to automate numerous processes.

However, the key lies not just in automation but in strategically harnessing the full potential of these automated processes. This strategic approach has the potential to achieve optimal results by integrating technological advancements with the human dimension of urban life. By finding a harmonious balance between technological innovation and human-centric design, we can pave the way for the realization of a smarter city that prioritizes the well-being of its residents.

This doctoral thesis is important as it addresses complex global issues, which are faced by cities all over the world. The research is broadly relevant across diverse cultural and geographical applications. Given its novelty and the interest of both public authorities and collaborative citizen initiatives, conducting research in this area is facilitated by the availability of open and accessible data for analysis. The widespread sharing of data processing codes further simplifies the utilization of pre-existing programming. Consequently, the findings can be shared for application in other mixed-method research.

The guiding question was: How can big data and citizen participation be integrated into a process for smart urban mobility? Our hypothesis was that design could enhance access to extensive urban data through data storytelling and participatory processes. First, we tackled real project issues, and then, we tested the solutions identified to increase citizen participation and make urban data more accessible. We integrated big data with citizen participation through various data collection techniques, such as municipal open data auditing, urban diaries, and social media analysis. These mixed data were then co-analyzed in a participatory process using digital data storytelling. Despite the vast amount of data, participants were able to generate numerous relevant insights. Affinity and empathy mapping activities successfully synthesized data, creating user profiles that formed the foundation for subsequent user journey development. A large amount of complex data was analyzed by individuals with diverse characteristics. If it were analyzed solely by one stakeholder, it would not bring such a diversity of views and perspectives, so rich for the city's context.

9.
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Appendix A: Ethics committee approval

PONTIFÍCIA UNIVERSIDADE CATÓLICA
DO RIO DE JANEIRO

CÂMARA DE ÉTICA EM PESQUISA DA PUC-Rio
Parecer da Comissão da Câmara de Ética em Pesquisa da PUC-Rio 74/2022 – Protocolo 87/2022
Proposta SGOC 439237

A Câmara de Ética em Pesquisa da PUC-Rio foi constituída como uma Câmara específica do Conselho de Ensino e Pesquisa conforme decisão deste órgão colegiado com atribuição de avaliar projetos de pesquisa do ponto de vista de suas implicações éticas.

Identificação:

Título: "Design centrado no cidadão em cidades inteligentes: processo de pesquisa integrando dados mistos no serviço de mobilidade" (Departamento de Artes e Design da PUC-Rio)
Autora: Raquel Corrêa Cordeiro (Doutoranda do Departamento de Artes e Design da PUC-Rio)
Orientadora: Maria Manuela Quaresma (Professora do Departamento de Artes e Design da PUC-Rio)

Apresentação: A pesquisa visa desenvolver um processo de co-design utilizando métodos mistos para pesquisa de mobilidade. O projeto prevê realização de análise dos sentimentos a partir dos comentários na rede social Twitter. Será também utilizado o diário de uso, técnica que registra dados durante um período definido e serão realizados workshops de co-design, com pessoas adultas das cidades do Rio de Janeiro e de Copenhague.

Aspectos éticos: O projeto e os Termos de Consentimento Livre e Esclarecido apresentados estão de acordo com os princípios e valores do Marco Referencial, Estatuto e Regimento da Universidade no que se refere às responsabilidades de seu corpo docente e discente. Os Termos expõem com clareza os objetivos da pesquisa e os procedimentos a serem seguidos. Garantem o sigilo e a confidencialidade dos dados coletados. Informam sobre a possibilidade de interrupção na pesquisa sem aplicação de qualquer penalidade ou constrangimento.

Parecer: Aprovado

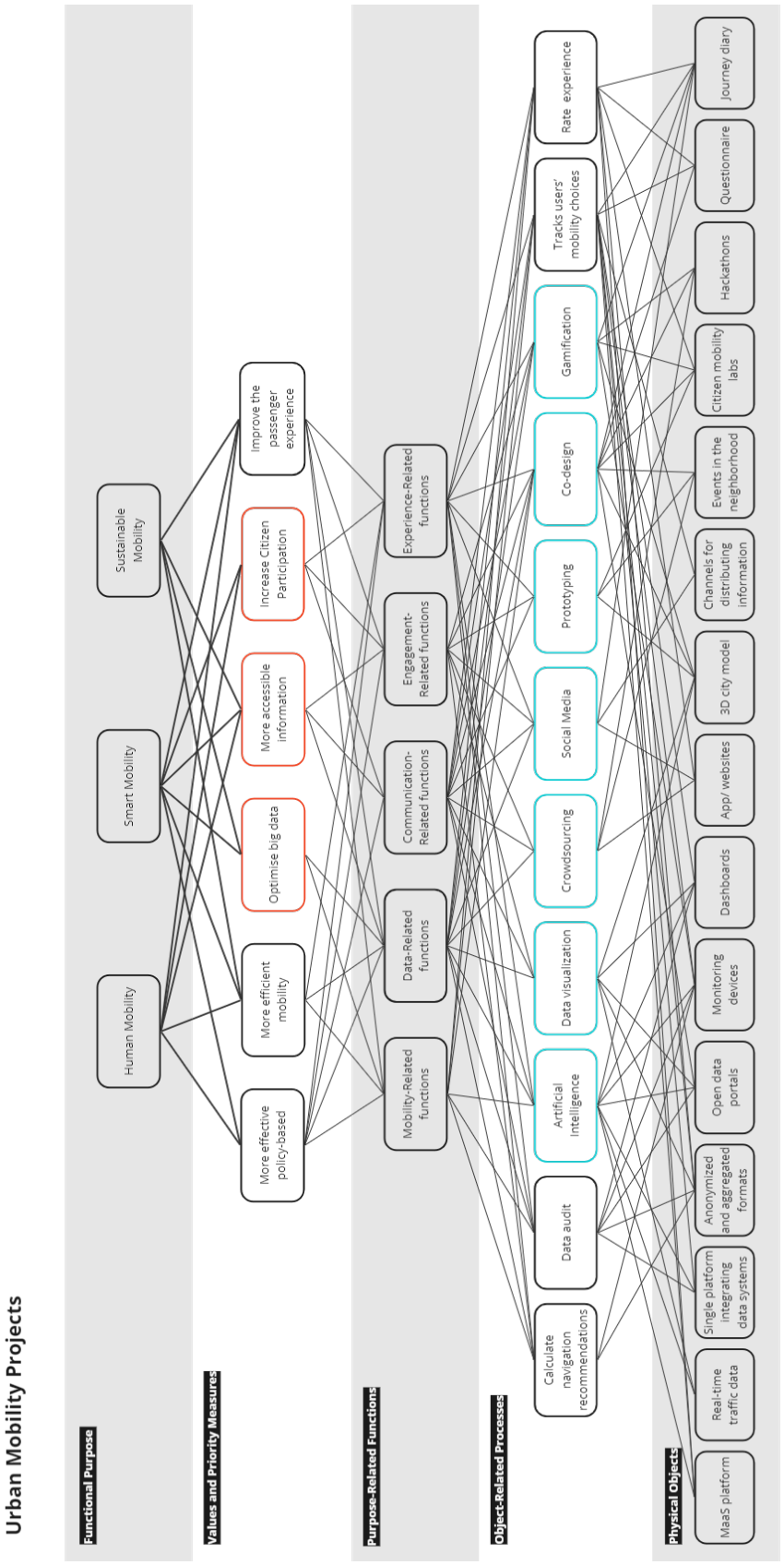
p/ Prof. José Ricardo Bergmann
Presidente do Conselho de Ensino e Pesquisa da PUC-Rio

Prof. Antonio Carlos de Oliveira
Comissão da Câmara de Ética em Pesquisa da PUC-Rio

Rio de Janeiro, 09 de setembro de 2022

Vice-Reitoria para Assuntos Acadêmicos
Câmara de Ética em Pesquisa da PUC-Rio – CEPq/PUC-Rio
Rua Marquês de São Vicente, 225 - Gávea – 22453-900
Rio de Janeiro – RJ – Tel. (021) 3527-1612 / 3527-1618
e-mail: vrac@puc-rio.br

Appendix B: Work Domain Analysis



Appendix C: Expert Interview Consent Form

CBS COPENHAGEN BUSINESS SCHOOL HANDELSHØJSKOLEN

PONTIFÍCIA UNIVERSIDADE CATÓLICA DO RIO DE JANEIRO

Consent form

Study title: Citizen Centred Design in Smart Cities
Principal Researcher: Raquel Corrêa Cordeiro, PhD candidate at Puc-Rio and visiting researcher at CBS.
Professor Advisor (Puc-Rio): Manuela Quaresma, D.Sc.
Departament of Arts & Design
Pontifical Catholic University of Rio de Janeiro
Professor Advisor (CBS): Isabel Fróes, PhD
Department of Management, Society and Communication
Copenhagen Business School

Purpose
Identify challenges and solutions in the research process of citizen participation projects.

Description
This interview will consist of open-ended questions about work processes, management of urban data, and design experiences.

Risks and benefits
There is no risk associated with this study.

Payments
You will receive no financial incentive.

Consent
Please note that it is optional for you to sign this consent form, i.e. it will not have any consequences for you if you do not wish to give your consent. The researchers will not use or store media of you if you have not given your consent.

You are at any time permitted to withdraw your consent by sending an e-mail to the Puc-Rio/CBS Data Protection Officer. If you withdraw your consent, this does not affect the use of media that have already been published in printed formats, but it will prevent media from being used after you have withdrawn your consent.

Research Ethics Committee of PUC-Rio
Marquês de São Vicente, 225 –Kennedy Building, 2° floor, Gávea, Rio de Janeiro, RJ. 22453-900. Phone: +55 (21) 3527-1618.

CBS' Data Protection Officer
Jesper Smedegaard Madsen - CBS Legal. Phone: +45 3815 2117. Mobile: +45 4185 2485. E-mail: dpo@cbs.dk

For how long will media be stored
Media will be stored from the time they are taken or recorded until it is no longer necessary in order to meet the above purposes, i.e. the researchers will store photographs until you withdraw your consent. The media will, however, not be stored for more than 10 years.

Your rights
In accordance with the General Data Protection Regulation, you have the right to:

- withdraw your consent and have media of you deleted.
- be informed of which media of you the researcher has stored and is using as well as a right to receive a copy of these media.

The above rights can be exercised by contacting the Data Controller or the Data Protection Officer.

Contact information
Questions, Concerns, or Complaints. If you have any questions or require any further information, please contact the protocol director.

Name of experimenter: Raquel Corrêa Cordeiro
Phone: +55 (21) 989913785 or +45 91647091
E-mail: raquelcordeiro@aluno.puc-rio or rcc.msc@cbs.dk

Data collected
All comments given by participants will be recorded for future analysis. The data, photo, video and audio, will be confidential and restricted to the researchers. Your name or material indicating your participation will not be released without your permission.

By signing below, I give Raquel Cordeiro (PUC-CBS) permission to use for academic purposes - papers, classes, presentations at scientific congresses related to the topic - the following data:

- ☐ I consent to publish my statements.
- ☐ I consent to publish photos, videos, and audio.
- ☐ I consent to publish my name.
- ☐ I do not consent to publish any data.

Full name (please use capital letters)	
Signature	Date of signature (DD/MM-YYYY)

Appendix D: Interview script with experts

📋

Interview Script

Date:

Participant Name:

Company:

Introduction

My name is Raquel Cordeiro. I am a PhD candidate from Puc-Rio, Brazil, and a visiting researcher at Copenhagen Business School.

My research focuses on service design and citizen participation in smart cities. I **aim** to identify challenges and solutions in the research process of citizen participation projects.

This interview will consist of open-ended questions about work processes, management of urban data, and design experiences.

I want to record audio and take pictures for future analysis. However, I will only publish your name or material if you give me permission.

So, here is a consent form for your information:

☐ (Consent Form signed)

Thank you, now I will start to record:

☐ (Start recording)

Warm-up

☐ Tell me about your **education and career history. Where have you worked and** what did you study? How did your experiences lead you to here?

☐ What is the workflow in the **lab**? How many people work here? How are they grouped? What kind of professionals?

Main Questions

☐ How are the **projects progressing**? Can you explain the process, including phases and workflow? Could you provide some examples?

(In case they haven't mentioned data)

☐ What types of **data** are generated? What is **open** to society?

☐ How is the Citizen Participation?

☐ How is the mixed **data integration**?

(If they haven't mentioned specific solutions)

☐ Do you have any projects that used **social media** as a data source? Can you tell me more about this process?

☐ And about **gamification**? What is your strategy to engage the participants?

☐ What was the strategy for improving **data visualization**? How have you made the data more accessible to citizens?

☐ Can you tell me more about the process of **co-design**? For example, what kind of activities you carried out to co-analyse the data?

Closing questions

We are going to the final questions.

☐ Do you have any feedback, challenges, or suggestions on this topic?

☐ Is there anyone you would recommend I talk to?

Closing and acknowledgement

Thank you for your participation. I will use these findings to develop an experimental discovery process in Rio next year.

Appendix E: Consent form for contextual interview

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Título da Pesquisa: Design centrado no cidadão em cidades inteligentes
Processo de pesquisa integrando dados mistos no serviço de mobilidade
Pesquisador responsável: Raquel Corrêa Cordeiro
Professora Orientadora: Prof. Dra. Manuela Quaresma
Programa de Pós-Graduação em Design
Pontifícia Universidade Católica do Rio de Janeiro/ Departamento de Artes e Design

Gostaríamos de convidar você a participar como voluntário (a) de uma **entrevista contextual**.

Justificativa
O motivo que nos leva a realizar esta pesquisa é trazer para o ambiente acadêmico problemas urbanos complexos e atuais. Entender o comportamento dos cidadãos exige um conhecimento das motivações pessoais, por isso uma pesquisa na área de design e de interação humano-computador, como essa, combina soluções tecnológicas com integração social.

Objetivo
Nesta pesquisa pretendemos avaliar a experiência do usuário navegando no banco de dados da prefeitura do Rio de Janeiro. Gostaríamos de analisar as dificuldades encontradas para utilizar os dados urbanos disponíveis para a população. Terminada a investigação, pretendemos também publicar a pesquisa em revistas acadêmicas e em anais de congressos.

Procedimentos
Caso concorde em participar, vamos fazer as seguintes atividades com você. Pediremos que entre no site da prefeitura (https://www.data.rio/) e busque um conjunto de dados do seu interesse para criar uma visualização. Enquanto você explora o site, a pesquisadora responsável irá fazer perguntas sobre a sua experiência de interação. Depois de terminada a sessão, será enviado digitalmente um questionário para entender a usabilidade do sistema.

Riscos
Esta pesquisa tem alguns riscos: possíveis desconfortos ou constrangimentos em compartilhar suas opiniões. Mas, para diminuir a chance desses riscos acontecerem, asseguramos que o procedimento do qual você participará visa somente entender as opiniões sobre o site Data Rio, assim, você não será testado(a) ou julgado(a).

Benefícios
Você não irá se beneficiar de forma direta ao participar deste estudo. No entanto, sua participação é vital para a compreensão das percepções dos cidadãos sobre banco de dados urbanos. Além de ajudar a moldar serviços mais adequados para a população.

Custos e compensação
Para participar deste estudo você não vai ter nenhum custo e nem receberá qualquer vantagem financeira. Apesar disso, se você tiver algum dano causado por atividades que fizermos com você nesta pesquisa, você tem direito a indenização.

Informações coletadas, confidencialidade e sigilo
Todas os comentários dados pelos participantes serão registrados para análise futura. Os dados serão confidenciais, restritos apenas às pesquisadoras. Os resultados da pesquisa estarão à sua disposição quando finalizada, e após a defesa a tese será publicada na biblioteca da Puc-Rio. Seu nome ou o material que indique sua participação não será liberado sem a sua permissão.

Autorização para uso de imagem e declarações
Mediante ao disposto no Artigo 9º da Resolução 510/16 CNS no que diz: *"São direitos dos participantes": "V – decidir se sua identidade será divulgada e quais são, dentre as informações que forneceu, as que podem ser tratadas de forma pública;"*. O material que constitui o corpo de dados coletados (imagens e áudio) não será divulgado. Você autoriza o uso de suas declarações para finalidades acadêmicas - artigos acadêmicos, aulas, papers, sites, apresentações em simpósios ou congressos científicos relacionados ao tema?
( ) Autorizo a divulgação das minhas declarações.
( ) Não autorizo a divulgação das minhas declarações.

Direitos dos participantes
Você terá todas as informações que quiser sobre esta pesquisa e estará livre para participar ou recusar-se a participar. Mesmo que você queira participar agora, você pode voltar atrás ou parar de participar a qualquer momento. A sua participação é voluntária e o fato de não querer participar não vai trazer qualquer penalidade. Este termo de consentimento encontra-se em duas vias originais, sendo que uma será arquivada pelo pesquisador responsável e a outra será fornecida a você. Esse documento será enviado a você por email, e será assinado pela pesquisadora e pelo participante.

Os dados coletados na pesquisa ficarão arquivados com o pesquisador responsável por um período de 5 (cinco) anos. Decorrido este tempo, o pesquisador avaliará os documentos para a sua destinação final, de acordo com a legislação vigente. Os pesquisadores tratarão a sua identidade com padrões profissionais de sigilo, utilizando as informações somente para os fins acadêmicos e científicos. Este termo respeita a Resolução 510/16 CS. Se você tiver alguma dúvida sobre esta pesquisa pode entrar em contato com a pesquisadora responsável pelo telefone (21) 98991-3785 ou pelo email raquelcordeiro@aluno.puc-rio.br ou com a professora orientadora ((21)3527-1005 ou mquaresma@puc-rio.br).

Concordo em participar da pesquisa e que me foi dada à oportunidade de ler e esclarecer as minhas dúvidas.

Rio de Janeiro, _____ de _____ de 20 .

_____ Assinatura do Participante

_____ Assinatura do (a) Pesquisador (a)

Departamento de Artes e Design
Programa de Pós-graduação em design da PUC-Rio

Appendix F: DataRio contextual interview script

Contextual Interview

Objective: In this research, we aim to evaluate the user experience while navigating the Rio de Janeiro database. We would like to analyze the difficulties encountered in using the urban data available to the public.

Research Question: What are the difficulties encountered in accessing the open data of the city of Rio de Janeiro?

Script

1. How do you like the website so far?
2. Do you already know what you're looking for, or are you just taking a general look at what's available?
3. What is your strategy for starting your search?
4. Are you able to find the specific database you are looking for?
5. Can you understand the items present in each table?
6. Do you know the format of the data?
7. Do you know how to download and use the information from these tables?

Appendix G: DataRio SUS questionnaire

Avaliação do site Data Rio

Pretendemos avaliar como foi a sua experiência navegando no banco de dados da prefeitura do Rio de Janeiro.

raquelcorreacordeiro@gmail.com Alternar conta

Não compartilhado

* Indica uma pergunta obrigatória

Nome Completo *

Sua resposta

Idade *

Sua resposta

Qual é o seu nível de experiência utilizando banco de dados? *

- Iniciante: nunca tinha trabalhado com banco de dados antes.
- Intermediário: utilizei banco de dados algumas vezes, mas ainda estou aprendendo.
- Avançado: utilizo regularmente banco de dados e tenho conhecimento avançado em análise de dados.
- Especialista: tenho experiência profissional extensa em trabalhar com banco de dados e sou considerado um especialista na área.
- Não sei/não tenho certeza: tenho alguma experiência, mas não tenho certeza de qual é meu nível de habilidade em utilizar banco de dados.

Próxima Página 1 de 3 Limpar formulário

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Google Formulários

Avaliação da usabilidade do Data Rio

Responda as afirmações a seguir onde: (1) Discordo Completamente (2) Discordo (3) Nem concordo nem discordo (4) Concordo (5) Concordo Completamente

1. Eu gostaria de usar este site com freqüência. *

	1	2	3	4	5	
Discordo Completamente	○	○	○	○	○	Concordo Completamente

2. Eu achei o site desnecessariamente complexo. *

	1	2	3	4	5	
Discordo Completamente	○	○	○	○	○	Concordo Completamente

3. Eu achei o site fácil de usar. *

	1	2	3	4	5	
Discordo Completamente	○	○	○	○	○	Concordo Completamente

4. Eu precisaria do apoio de uma pessoa técnica para utilizar este site. *

	1	2	3	4	5	
Discordo Completamente	○	○	○	○	○	Concordo Completamente

5. Eu achei as várias funções deste site bem integradas. *

	1	2	3	4	5	
Discordo Completamente	○	○	○	○	○	Concordo Completamente

6. Eu achei que havia muita inconsistência neste site. *

	1	2	3	4	5	
Discordo Completamente	○	○	○	○	○	Concordo Completamente

7. A maioria das pessoas aprenderia como usar este site rapidamente. *

	1	2	3	4	5	
Discordo Completamente	○	○	○	○	○	Concordo Completamente

8. Eu achei o site muito confuso de usar. *

	1	2	3	4	5	
Discordo Completamente	○	○	○	○	○	Concordo Completamente

9. Eu me senti muito confiante ao usar o site. *

	1	2	3	4	5	
Discordo Completamente	○	○	○	○	○	Concordo Completamente

10. Eu precisei aprender várias coisas novas antes de conseguir usar o site. *

	1	2	3	4	5	
Discordo Completamente	○	○	○	○	○	Concordo Completamente

Voltar Próxima Página 2 de 3 Limpar formulário


Avaliação do site Data Rio
raquelcorreacordeiro@gmail.com Alternar conta
Não compartilhado
Nesta seção vamos fazer perguntas opcionais sobre sua experiência no site Data Rio
Qual foi o seu maior desafio utilizando o site?
Sua resposta
Você tem alguma sugestão de como poderia melhorar o acesso aos dados?
Sua resposta
Voltar
Enviar
Página 3 de 3
Limpar formulário
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Google Formulários

Appendix H: Diary Study recruitment form

Experiência Cidadã

Gostaríamos de convidar você a participar como voluntário(a) de um **Diário de Uso**. Essa é uma etapa da pesquisa de doutorado da aluna Raquel Cordeiro, sob orientação da Professora Dra. Manuela Quaresma, no Programa de Pós-Graduação em Design da Puc-Rio.

raquelcorreacordeiro@gmail.com Alternar conta

Não compartilhado

* Indica uma pergunta obrigatória

Procedimento

Nesta pesquisa pretendemos avaliar a sua **experiência** em cada meio de **transporte** e a relação com o **clima**.

Caso você concorde em participar, vamos fazer as seguintes atividades:

1. Será solicitado que se **locomova** normalmente pela **cidade** e preencha um **diário** relatando sua **experiência** em diferentes condições **climáticas**.
2. A coleta de dados será durante todo o mês de **março**.
3. A pesquisa será compartilhada nos **stories** de uma conta no **Instagram** seguida pelos participantes.
4. Iremos perguntar informações como **meio de locomoção** utilizado, **motivo da viagem**, **bairros** percorridos, **sensação térmica**, condições **climáticas** e **satisfação** da viagem.

Os participantes seguirão um perfil no Instagram que divulgará informações sobre o tráfego e estatísticas de viagem, evolução durante o "desafio", posição em relação aos outros participantes, troféus e recompensas. O respondente com maior engajamento será presenteado com uma arte personalizada com um resumo dos seus dados.

Aceite *

Clique aqui para ler o Termo de Consentimento Livre e Esclarecido.

☐ Concordo em participar da pesquisa e que me foi dada à oportunidade de ler e esclarecer as minhas dúvidas.

Próxima Página 1 de 2 Limpar formulário

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Google Formulários

Informações pessoais

Nome Completo *

Sua resposta

Idade *

Sua resposta

Região de moradia *

Escolher

Com qual gênero você se identifica? *

- ◯ Feminino
- ◯ Masculino
- ◯ Outro
- ◯ Prefiro não informar

Qual a frequência você se deslocou em cada meio de transporte, nos últimos meses? *

	Muito Frequentemente (Diariamente)	Frequentemente (Várias vezes por semana)	Ocasionalmente (Algumas vezes por mês)	Raramente (Algumas vezes por ano)	Nunca
Ônibus	◯	◯	◯	◯	◯
Trem/Metrô/VLT	◯	◯	◯	◯	◯
Bicicleta	◯	◯	◯	◯	◯
Barca	◯	◯	◯	◯	◯
Táxi/Carro próprio	◯	◯	◯	◯	◯
A pé	◯	◯	◯	◯	◯

E-mail para contato *

Sua resposta

Telefone

Sua resposta

Link para perfil do Instagram *

Sua resposta

Voltar | Enviar | Página 2 de 2 | Limpar formulário

Appendix I: Consent form for participation in the diary study

Artes & Design PUC-Rio | LEUI PUC-Rio

Pontifícia Universidade Católica do Rio de Janeiro

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Título da Pesquisa: Design centrado no cidadão em cidades inteligentes
Processo de pesquisa integrando dados mistos no serviço de mobilidade
Pesquisador responsável: Raquel Corrêa Cordeiro
Professora Orientadora: Prof. Dra. Manuela Quaresma
Programa de Pós-Graduação em Design
Pontifícia Universidade Católica do Rio de Janeiro/ Departamento de Artes e Design

Gostaríamos de convidar você a participar como voluntário (a) de uma pesquisa de **Diário de Uso**.

Justificativa
O motivo que nos leva a realizar esta pesquisa é trazer para o ambiente acadêmico problemas urbanos complexos e atuais. Entender o comportamento dos cidadãos exige um conhecimento das motivações pessoais, por isso uma pesquisa na área de design e de interação humano-computador, como essa, combina soluções tecnológicas com integração social. A crise climática necessita urgentemente de uma visão multidisciplinar, e o design pode contribuir sendo uma ponte que une a sociedade, a academia e o governo.

Objetivo
Nesta pesquisa pretendemos avaliar a experiência do cidadão em cada meio de transporte e sua relação com o clima. Para assim desenvolver um processo que utilize diferentes métodos para projetos de mobilidade. Terminada a investigação, pretendemos também publicar a pesquisa em revistas acadêmicas e em anais de congressos.

Procedimentos
Caso você concorde em participar, vamos fazer as seguintes atividades com você. Será solicitado que se locomova normalmente pela cidade e preencha um diário relatando sua experiência em diferentes condições climáticas. A coleta de dados terá o período de um mês e será feita por meio da rede social Instagram. Iremos perguntar informações como meio de locomoção utilizado, motivo da viagem, bairros percorridos, sensação térmica, condições climáticas e satisfação da viagem.

Depois iremos trazer elementos lúdicos para incentivar o preenchimento do diário com informações sobre o tráfego e estatísticas de viagem, mostrando a evolução durante o "desafio", posição em relação aos outros participantes, troféus e recompensas. O participante "ganhador" será presenteado com uma arte personalizada com um resumo dos seus dados.

Riscos
Esta pesquisa tem alguns riscos: possíveis desconfortos ou constrangimentos em compartilhar suas opiniões e trajetos percorridos. Mas, para diminuir a chance desses riscos acontecerem, asseguramos que o procedimento do qual você participará visa somente entender as opiniões dos cidadãos se locomovendo pela cidade, assim, você não será testado(a) ou julgado(a). Todos os procedimentos serão realizados remotamente, não havendo riscos de contaminação da COVID-19.

Benefícios
Você não irá se beneficiar de forma direta ao participar deste estudo. No entanto, sua participação é vital para a compreensão das percepções dos cidadãos sobre a mobilidade urbana. Além de ajudar a moldar serviços mais adequados para a população.

Custos e compensação
Para participar deste estudo você não vai ter nenhum custo e nem receberá qualquer vantagem financeira. Apesar disso, se você tiver algum dano causado por atividades que fizermos com você nesta pesquisa, você tem direito a indenização.

Informações coletadas, confidencialidade e sigilo
Todas as respostas do diário dadas pelos participantes serão registradas para análise futura. Os dados serão confidenciais, restritos apenas às pesquisadoras. Os resultados da pesquisa estarão à sua disposição quando finalizada. Seu nome ou o material que indique sua participação não será liberado sem a sua permissão. Informações do perfil do Instagram do participante, como nome de usuário, poderão ser utilizadas para identificá-lo no ranking de engajamento. A imagem do perfil poderá ser utilizada para a arte de premiação.

Autorização para uso de imagem e declarações
Mediante ao disposto no Artigo 9º da Resolução 510/16 CNS no que diz: *"São direitos dos participantes": "V – decidir se sua identidade será divulgada e quais são, dentre as informações que forneceu, as que podem ser tratadas de forma pública;".* Autorizo que poderão ser divulgadas, para finalidades acadêmicas:
( ) Autorizo a divulgação das minhas declarações.
( ) Autorizo a divulgação da minha foto de perfil do Instagram.
( ) Autorizo a divulgação do meu nome de usuário do Instagram.
( ) Não autorizo a divulgação de nenhum dado.

Direitos dos participantes
Você terá todas as informações que quiser sobre esta pesquisa e estará livre para participar ou recusar-se a participar. Mesmo que você queira participar agora, você pode voltar atrás ou parar de participar a qualquer momento. A sua participação é voluntária e o fato de não querer participar não vai trazer qualquer penalidade ou mudança na forma em que você é atendido (a). Este termo de consentimento encontra-se em duas vias originais, sendo que uma será arquivada pelo pesquisador responsável e a outra será fornecida a você. Esse documento será enviado a você por email, e serão assinadas pela pesquisadora e pelo participante.

Os dados coletados na pesquisa ficarão arquivados com o pesquisador responsável por um período de 5 (cinco) anos. Decorrido este tempo, o pesquisador avaliará os documentos para a sua destinação final, de acordo com a legislação vigente. Os pesquisadores tratarão a sua identidade com padrões profissionais de sigilo, utilizando as informações somente para os fins acadêmicos e científicos. Este termo respeita a Resolução 510/16 CS e foi avaliado pela Câmara de Ética em Pesquisa da PUC-Rio. Se você tiver alguma dúvida sobre esta pesquisa pode entrar em contato com a pesquisadora responsável pelo telefone (21) 98991-3785 ou pelo email raquelcordeiro@aluno.puc-rio.br ou com a professora orientadora ((21)3527-1005 ou mquaresma@puc-rio.br).

Declaro que concordo em participar da pesquisa e que me foi dada à oportunidade de ler e esclarecer as minhas dúvidas.

Rio de Janeiro, _____ de _____ de 20 .

_____ Assinatura do Participante

_____ Assinatura do (a) Pesquisador (a)

Departamento de Artes e Design
Programa de Pós-graduação em design da PUC-Rio
Câmara de Ética em Pesquisa da PUC-Rio
Rua Marquês de São Vicente, 225 – Edifício Kennedy, 2º andar, Gávea, Rio de Janeiro, RJ. CEP: 22453-900.
Telefone: (21) 3527-1618.
A Câmara tem por atribuição analisar do ponto de vista ético os projetos de pesquisa dos professores, pesquisadores e discentes da Universidade, quando solicitada.

Appendix J: Diary Experience Assessment Questionnaire

Questionário sobre o diário de viagens

Olá! Agradecemos por ter participado da nossa pesquisa. Gostaríamos de convidá-lo para responder a um breve questionário pós-teste, que levará cerca de 5 a 10 minutos para ser concluído. As perguntas estão relacionadas à sua experiência na pesquisa.

raquelcorreacordeiro@gmail.com Alternar conta

Não compartilhado

* Indica uma pergunta obrigatória

Qual a frequência você entra no Instagram? *

- ◯ Muito frequentemente, várias vezes por dia.
- ◯ Frequentemente, uma vez por dia.
- ◯ Ocasionalmente, várias vezes por semana.
- ◯ Raramente, uma vez por semana.
- ◯ Quase não entro, não lembro a frequência.

Você respondeu sobre os seus deslocamentos durante o mês de março? *

- ◯ Sim, todos os dias.
- ◯ Sim, quase todos os dias.
- ◯ Registrei algumas viagens quando lembrava.
- ◯ Pouco, registrei no máximo 5 deslocamentos.
- ◯ Não registrei nenhuma viagem.

Próxima Limpar formulário

Para quem não participou da pesquisa.

Você pode selecionar mais de uma resposta.

Porque você não participou ou registrou poucos deslocamentos? *

- ☐ Não costumo entrar no Instagram.
- ☐ Achei difícil o sistema.
- ☐ Não lembrei.
- ☐ Não recebi mensagens lembrando.
- ☐ Não vi os stories.
- ☐ Não entendi a pesquisa.
- ☐ Estava sem tempo.
- ☐ Viagem/ausência da cidade.
- ☐ Outro: _____

Voltar Próxima Limpar formulário

Para quem participou da pesquisa

Você pode selecionar mais de uma resposta.

Quando você fazia os registros das viagens? *

- [ ] Sempre que me deslocava.
- [ ] Só quando lembrava.
- [ ] Quando via os stories.
- [ ] Quando tinha algo relevante para preencher.
- [ ] Anotava em outro lugar e depois enviava para a pesquisadora.
- [ ] Outro: _____

Qual foi a sua motivação para preencher o diário? *

- [ ] Acho importante a participação cidadã.
- [ ] O esforço era pequeno.
- [ ] Gostaria de ajudar na pesquisa.
- [ ] Gostaria de ganhar o desafio.
- [ ] Não me senti motivada.
- [ ] Outro: _____

Pense na sua experiência ao responder a pesquisa de modo geral. Leia as frases e responda se concorda ou discorda das afirmações.

Achei fácil responder sobre os meus deslocamentos. *

	1	2	3	4	5	
Discordo	○	○	○	○	○	Concordo

Eu fiquei satisfeita(o) com o tempo para completar os registros. *

	1	2	3	4	5	
Discordo	○	○	○	○	○	Concordo

Eu fiquei satisfetita(o) com o suporte que recebi para responder a pesquisa. *
(Instruções, tutorial, assistência da pesquisadora)

	1	2	3	4	5	
Discordo	○	○	○	○	○	Concordo

Achei fácil usar o Instagram porque é uma rede social que já estou acostumada. *

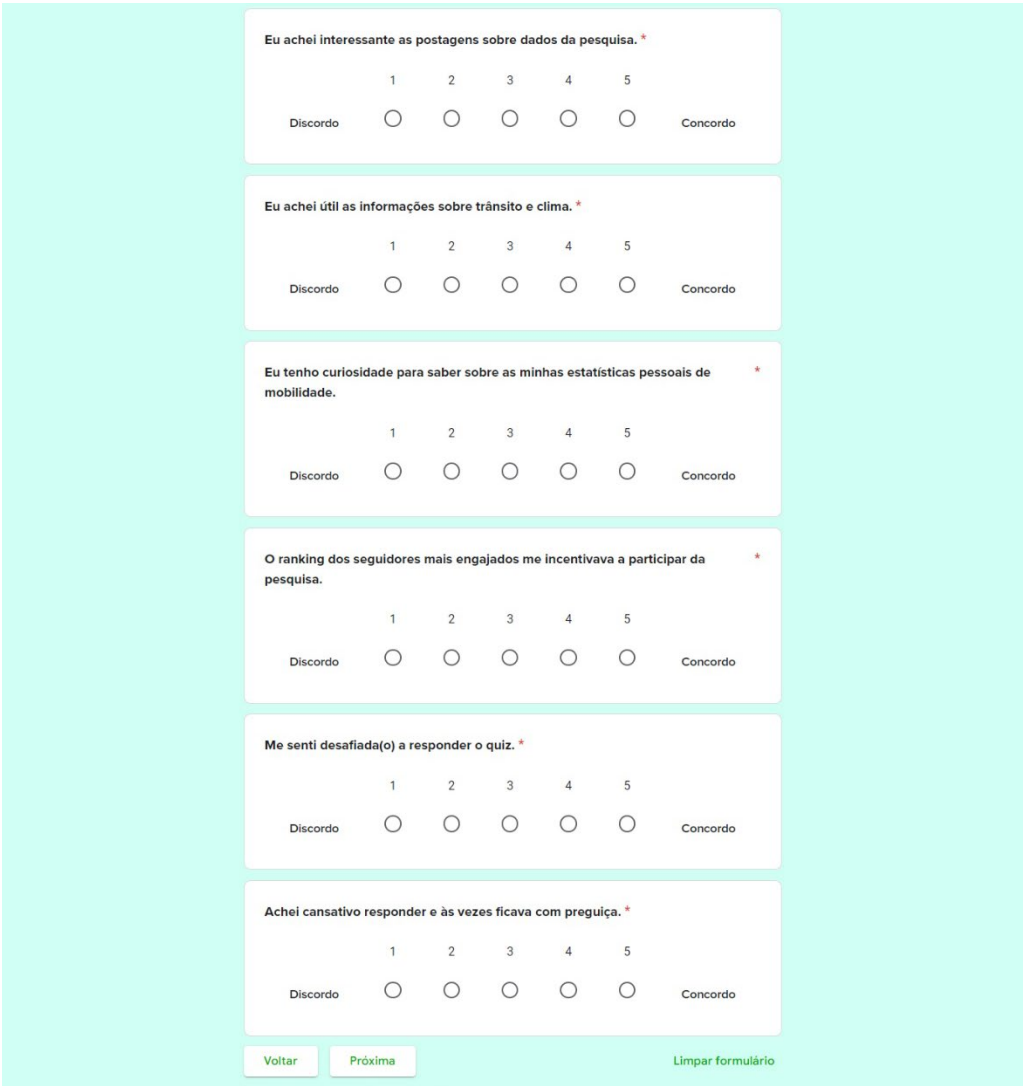
	1	2	3	4	5	
Discordo	○	○	○	○	○	Concordo

Sempre que eu entrava no Instagram via as postagens da pesquisa. *

	1	2	3	4	5	
Discordo	○	○	○	○	○	Concordo

Tive um esforço inicial para aprender como responder a pesquisa mas depois entendi como funcionava. *

	1	2	3	4	5	
Discordo	○	○	○	○	○	Concordo



Eu achei interessante as postagens sobre dados da pesquisa. *

	1	2	3	4	5	
Discordo	○	○	○	○	○	Concordo

Eu achei útil as informações sobre trânsito e clima. *

	1	2	3	4	5	
Discordo	○	○	○	○	○	Concordo

Eu tenho curiosidade para saber sobre as minhas estatísticas pessoais de mobilidade. *

	1	2	3	4	5	
Discordo	○	○	○	○	○	Concordo

O ranking dos seguidores mais engajados me incentivava a participar da pesquisa. *

	1	2	3	4	5	
Discordo	○	○	○	○	○	Concordo

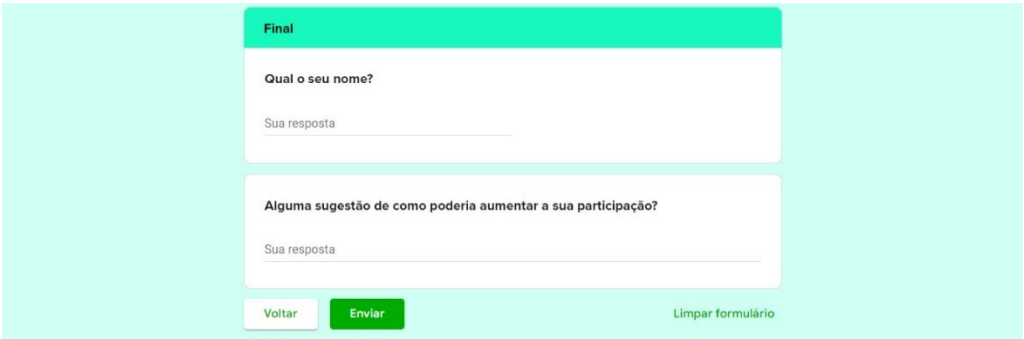
Me senti desafiada(o) a responder o quiz. *

	1	2	3	4	5	
Discordo	○	○	○	○	○	Concordo

Achei cansativo responder e às vezes ficava com preguiça. *

	1	2	3	4	5	
Discordo	○	○	○	○	○	Concordo

Voltar Próxima Limpar formulário



Final

Qual o seu nome?

Sua resposta

Alguma sugestão de como poderia aumentar a sua participação?

Sua resposta

Voltar Enviar Limpar formulário

Appendix K: Consent form for participation in the workshop

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Título da Pesquisa: Design centrado no cidadão em cidades inteligentes
Processo de pesquisa integrando dados mistos no serviço de mobilidade
Pesquisador responsável: Raquel Corrêa Cordeiro
Professora Orientadora: Prof. Dra. Manuela Quaresma
Programa de Pós-Graduação em Design
Pontifícia Universidade Católica do Rio de Janeiro/ Departamento de Artes e Design

Gostaríamos de convidar você a participar como voluntário (a) de um **workshop de co-design**.

Justificativa
O motivo que nos leva a realizar esta pesquisa é trazer para o ambiente acadêmico problemas urbanos complexos e atuais. Entender o comportamento dos cidadãos exige um conhecimento das motivações pessoais, por isso uma pesquisa na área de design e de interação humano-computador, como essa, combina soluções tecnológicas com integração social. A crise climática necessita urgentemente de uma visão multidisciplinar, e o design pode contribuir sendo uma ponte que une a sociedade, a academia e o governo.

Objetivo
Nesta pesquisa pretendemos avaliar a experiência do cidadão em cada meio de transporte e sua relação com o clima. Para assim desenvolver um processo que utilize diferentes métodos para projetos de mobilidade. Terminada a investigação, pretendemos também publicar a pesquisa em revistas acadêmicas e em anais de congressos.

Procedimentos
Caso você concorde em participar, vamos fazer as seguintes atividades com você. Reuniremos cidadãos para discutir padrões de comportamento na mobilidade urbana relacionados ao clima. Os dados urbanos provenientes de pesquisas prévias serão analisados em grupo, por meio de uma dinâmica, para entender o que motiva os comportamentos, bem como gerar ideias para mobilidade urbana.

Idealmente, o workshop será presencial, mas, caso haja algum empecilho, podemos adaptar as dinâmicas para serem remotas. O tempo previsto de duração será entre uma e duas horas. Dessa forma, o roteiro planejado será:

1. Apresentação da pesquisa – Identificando quem somos, os objetivos, metas e o que será esperado dos participantes;
2. Aquecimento – Dinâmica para quebrar o gelo e os participantes se familiarizarem uns com os outros;
3. Imersão – Utilização de técnicas de visualização de dados e narrativas digitais para apresentar os resultados das pesquisas já realizadas;
4. Análise – Mapa de empatia para agrupar as questões encontradas nas redes sociais e diários;
5. Fechamento – Agradecimento e explicação dos próximos passos da pesquisa.

Riscos
Esta pesquisa tem alguns riscos: possíveis desconfortos ou constrangimentos em compartilhar suas opiniões. Mas, para diminuir a chance desses riscos acontecerem, asseguramos que o procedimento do qual você participará visa somente entender as opiniões sobre mobilidade urbana, assim, você não será testado(a) ou julgado(a).

Benefícios
Você não irá se beneficiar de forma direta ao participar deste estudo. No entanto, sua participação é vital para a compreensão das percepções dos cidadãos sobre a mobilidade urbana. Além de ajudar a moldar serviços mais adequados para a população.

Custos e compensação
Para participar deste estudo você não vai ter nenhum custo e nem receberá qualquer vantagem financeira. Apesar disso, se você tiver algum dano causado por atividades que fizermos com você nesta pesquisa, você tem direito a indenização.

Informações coletadas, confidencialidade e sigilo
Todas os comentários dados pelos participantes serão registrados para análise futura. Os dados serão confidenciais, restritos apenas às pesquisadoras. Os resultados da pesquisa estarão à sua disposição quando finalizada, e após a defesa a tese será publicada na biblioteca da Puc-Rio. Seu nome ou o material que indique sua participação não será liberado sem a sua permissão.

Autorização para uso de imagem e declarações
Mediante ao disposto no Artigo 9º da Resolução 510/16 CNS no que diz: *"São direitos dos participantes": "V – decidir se sua identidade será divulgada e quais são, dentre as informações que forneceu, as que podem ser tratadas de forma pública;"*. O material que constitui o corpo de dados coletados (imagens e áudio) não será divulgado. Você autoriza o uso de suas declarações para finalidades acadêmicas - artigos acadêmicos, aulas, papers, sites, apresentações em simpósios ou congressos científicos relacionados ao tema?
( ) Autorizo a divulgação das minhas declarações.
( ) Não autorizo a divulgação das minhas declarações.

Direitos dos participantes
Você terá todas as informações que quiser sobre esta pesquisa e estará livre para participar ou recusar-se a participar. Mesmo que você queira participar agora, você pode voltar atrás ou parar de participar a qualquer momento. A sua participação é voluntária e o fato de não querer participar não vai trazer qualquer penalidade. Este termo de consentimento encontra-se em duas vias originais, sendo que uma será arquivada pelo pesquisador responsável e a outra será fornecida a você. Esse documento será enviado a você por email, e será assinado pela pesquisadora e pelo participante.

Os dados coletados na pesquisa ficarão arquivados com o pesquisador responsável por um período de 5 (cinco) anos. Decorrido este tempo, o pesquisador avaliará os documentos para a sua destinação final, de acordo com a legislação vigente. Os pesquisadores tratarão a sua identidade com padrões profissionais de sigilo, utilizando as informações somente para os fins acadêmicos e científicos. Este termo respeita a Resolução 510/16 CS e foi avaliado pela Câmara de Ética em Pesquisa da PUC-Rio. Se você tiver alguma dúvida sobre esta pesquisa pode entrar em contato com a pesquisadora responsável pelo telefone (21) 98991-3785 ou pelo email raquelcordeiro@aluno.puc-rio.br ou com a professora orientadora ((21)3527-1005 ou mquaresma@puc-rio.br).

Concordo em participar da pesquisa e que me foi dada à oportunidade de ler e esclarecer as minhas dúvidas.

Rio de Janeiro, _____ de _____ de 20 .

_____ _____
Assinatura do Participante Assinatura do (a) Pesquisador (a)

Departamento de Artes e Design
Programa de Pós-graduação em design da PUC-Rio
Câmara de Ética em Pesquisa da PUC-Rio
Rua Marquês de São Vicente, 225 – Edifício Kennedy, 2º andar, Gávea, Rio de Janeiro, RJ. CEP: 22453-900.
Telefone: (21) 3527-1618.
A Câmara tem por atribuição analisar do ponto de vista ético os projetos de pesquisa dos professores, pesquisadores e discentes da Universidade, quando solicitada.

Appendix L: Workshop script

Roteiro

06:30 - Preparação do espaço
( ) Papel com rótulo em cada mesa com o nome das regiões da cidade.

( ) Linhas coloridas presas em um mesmo ponto

( ) Boards, legos e cards separados por transporte

( ) Abrir as visualizações em cada computador

( ) Termo de consentimento impresso (20 cópias)

( ) Avaliação final impressa (20 cópias)

07:00 - Apresentação (5min)

Slide 1: Capa
Bom dia pessoal, bem-vindos ao workshop de Design de serviço na era digital: utilizando storytelling e visualização de dados para coanalisar problemas complexos.

Slide 2: Sobre
Meu nome é Raquel, sou pesquisadora de doutorado aqui na Puc. Minha pesquisa foca no processo de design centrado no cidadão em cidades inteligentes.

Slide 3: Objetivo do workshop
- O objetivo é criar uma **atividade colaborativa** que ajuda a entender problemas complexos utilizando **dados** provenientes da **cidade** e do **cidadão**. O exercício propõe uma imersão nos efeitos das condições **meteorológicas** na **mobilidade** urbana. Para criarmos uma **jornada** do **serviço** de **mobilidade**.
- Vou utilizar seus **feedbacks** desse workshop para a minha **tese**, por isso tenho aqui um **termo de consentimento** explicando como serão usados os seus dados.

( ) Distribuir os termos

Slide 4: Agenda
Essa será a nossa programação, vamos ter um relógio para um controle rigoroso do tempo

07:20 - Aquecimento (10 min)
Slide 5: Como foi a sua viagem?
- Hoje estava um dia quente/frio, com uma chuva/sol/nublado, como foi a experiência da viagem das suas casas até a universidade?
- Vamos todos ficar de pé e temos 4 mesas aqui: **Zona Sul** (Copacabana, Gávea, Botafogo...), **Zona Norte** (Tijuca, Penha, Meier...), **Zona Oeste** (Barra, Jacarepagua, Recreio...) e **Outros** (Centro, Lapa, Niteroi, Caxias...). Vão para as mesas de onde vocês vieram. Ok, aqui já podemos visualizar uma concentração de bairros da... Quando estamos analisando a cidade do Rio que é bem complexa, temos um recorte geográfico bem específico.
- Agora me respondam, como vocês vieram? Gostaria que vocês pegassem um **fio** com a cor de cada meio de **transporte**. (No slide tem a legenda). Ônibus, Carro, táxi, bicicleta, andando, metrô...
- Agora, quem teve uma experiência boa pode **levantar o braço**, neutra levanta até o ombro e quem não gostou deixa abaixado. Podemos visualizar muitas experiências diferentes, vários fatores interferem na mobilidade urbana. Então eu convido vocês para conhecerem outras histórias e pensarem juntos como podemos melhorar o deslocamento pela cidade.
- Vamos nos dividir em **grupos** de 5 pessoas. Vamos tentar misturar pessoas que vieram de diferentes meios de transporte (com linhas coloridas) e de diferentes partes da cidade.

07:30 - Imersão (15 min)

Slide 6: Contexto
- Os efeitos das **mudanças climáticas** fazem os dias ficarem mais **quentes**. Se locomover pela cidade pode ser um desafio dependendo do dia, do transporte, do local... Os dados que vou apresentar agora foram coletados para ajudar a gente a responder: Quais são os pontos positivos e negativos de cada meio de transporte nos dias quentes?
- Vocês tem post its nas mesas, enquanto estou apresentando vocês podem ir anotando caso tenham alguma coisa que queiram registrar.

( ) Ir para o slide 5

- Aqui vimos a **experiência de 20 pessoas** nessa viagem única até a Puc.

07:31 - Slide 7: Diário

- Porém, pedimos para outras 19 pessoas responderem um **diário** contando as suas experiências se deslocando pela cidade durante 1 mês, em março.
- Criei as imagens e os nomes por **IA** para não divulgar a identidade verdadeira dos participantes. Mas a amostragem tinha pessoas que se deslocavam por diferentes meios de transporte.
- No total eles fizeram **260 viagens**, alguns mais do que outros
- Fizeram esses registros durante o mês de **março** desse ano
- Responderam sobre o meio de **transporte**
- **Satisfação** da viagem
- Sensação **térmica**

- Elas tinham espaço para **comentar** livremente sobre o transporte, a cidade, o clima ou algo que fez elas mudarem de ideia.

07:35- Slide 8: Dados da cidade
- O governo e as empresas de transportes já tem muitos **dados** que poderiam nos ajudar a entender o comportamento de mobilidade.
- Então pedimos para os órgãos públicos e empresas responsáveis pelo transporte acesso aos dados de mobilidade da cidade do Rio e podemos ver qual o número de viagens nos onibus, taxi, barcas nesse verão.
- Integramos com os dados **meteoorológicos** da cidade
- Esse verão tivemos vários dias com temperatura a cima de 40C.

07:40- Slide 9: Twitter
- Pedir para as pessoas responderem por um mês é algo trabalhoso, e muitas vezes elas se esquecem de responder. Então extraímos mais de **36.000 tweets** nos últimos 15 anos usando as hashtags vinculadas aos meios de transporte do Rio. Depois cruzamos com as palavras relacionadas ao clima citadas no diário.
- Analisamos 3.514 tweets resultantes desse **cruzamento**.
- Separamos por hashtags relacionadas aos meios de transporte.
- Fizemos uma análise de sentimentos dessas postagens utilizando machine learning.
- E cruzamos com a temperatura máxima registrada no dia
- Esses depoimentos já estão disponíveis e foram postados voluntariamente pelos cidadãos.

07:45- Coanálise (45 min)

Quais serãos os desafios encontrados por nossos **personagens** para caminharem, andarem de bicicleta, metrô, ônibus ou barca pela cidade?

Slide 10: Mapa de afinidade (15 min)
- Agora em grupos, cada mesa tem dados de um meio de transporte e uma pessoa que vai representar essa experiência. Nas suas mesas têm os dados, as peças de lego representam as viagens do diário, fichas com os principais comentários do diário, computador com acesso aos dados mais detalhados.
- Com os post its eu gostaria que vocês escrevessem os principais achados da experiência de mobilidade desse meio de transporte. Estamos usando esse personagem para **ilustrar** o passageiro, mas podemos pegar informações de outras pessoas.
- Para exemplificar, tenho o caso da Gabriela que faz **caminhadas** para se exercitar. Nos post its escrevi informações que encontrei nas pesquisas.
- Vocês tem 15 minutos para escrever essas informações.

( ) Ativar o timer de 15 min

08:00- Clusterização (5 min)
Agora vou dar mais 5 minutos para vocês agruparem as questões encontradas **clusterizando** por tópicos. Por exemplo esses primeiros são informações relacionadas a atividade física. Esses outros estão relacionados ao calor. Então podem escrever em outro post it ou no papel mesmo.

( ) Ativar o timer de 5 min

08:05- Slide 11: Mapa de empatia (5 min)
Agora vocês podem levar os post its separando em o que pensa, sente, vê, fala, faz e ouve. Aqui vocês podem acrescentar mais informações que de repente vocês não escreveram antes ou que tenham lembrado agora. Podem **complementar** os dados. Por exemplo no caso da Gabriela ela sente muito calor, caminha suando muito... Vocês têm 5 minutos para organizar o mapa de empatia.

( ) Ativar o timer de 5 min

08:10- Slide 12: Jornada (20 min)
Com os achados criados e clusterizados desenhar as jornadas dos participantes, ressaltando as dores e dificuldades encontradas. Nessa última linha vocês podem escrever ideias de como poderiam **solucionar** essas dores encontradas. Vocês tem 15 minutos.

( ) Ativar o timer de 20 min

08:30- Resultados (15 min)

Slide 13: Apresentação (12 min)
Cada grupo apresenta o seu personagem e a jornada (3 min por grupo)

( ) Ativar o timer 3 min para cada

08:45- Fechamento (15 min)

Slide 14: Agradecimento

Obrigada por participarem, como eu expliquei no início, essa é uma etapa do meu doutorado, então é muito importante ouvir o feedback de vocês para melhorar e ajustar a dinâmica. Por isso, gostaria que vocês respondessem esse formulário sobre a sua experiência. Ele é anônimo, então é só preencher, dobrar e deixar aqui.

( ) Distribuir o formulário

Appendix M: Workshop evaluation questionnaire

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Pontifícia Universidade Católica do Rio de Janeiro

Questionário sobre o Workshop

Olá! Agradecemos por ter participado do nosso workshop. Gostaríamos de convidá-lo para responder a um breve questionário. As perguntas estão relacionadas à sua experiência.

Você já participou de workshops de co-design?

( ) Sim, já participei e facilitei
( ) Sim, participo frequentemente
( ) Sim, participei poucas vezes
( ) Não, foi minha primeira vez
( ) Não sei/ não lembro

Pense na sua experiência durante o workshop.
Leia as frases e responda se concorda ou discorda das afirmações.

A apresentação me ajudou a contextualizar as informações.
Discordo (1) (2) (3) (4) (5) Concordo

Eu fiquei satisfetita(o) com o suporte visual que recebi sobre os dados.
Discordo (1) (2) (3) (4) (5) Concordo

Achei os dados confusos de entender.
Discordo (1) (2) (3) (4) (5) Concordo

Tive um esforço inicial para aprender como interagir com os dados, mas depois entendi como funcionava.
Discordo (1) (2) (3) (4) (5) Concordo

Achei fácil manipular os dados.
Discordo (1) (2) (3) (4) (5) Concordo

Senti falta de receber os dados antes do workshop.
Discordo (1) (2) (3) (4) (5) Concordo

A dinâmica inicial sobre o meu trajeto (com fios) ajudou na identificação com o tema.
Discordo (1) (2) (3) (4) (5) Concordo

As peças de lego me ajudaram a tangibilizar a informação.
Discordo (1) (2) (3) (4) (5) Concordo

Eu fiquei satisfeita(o) com o tempo para a jornada.
Discordo (1) (2) (3) (4) (5) Concordo

Eu achei interessante as dinâmicas propostas.
Discordo (1) (2) (3) (4) (5) Concordo

Eu já conhecia dinâmicas parecidas utilizando visualizações de dados.
Discordo (1) (2) (3) (4) (5) Concordo

Eu achei inovador utilizar visualização de dados em processo participativo.
Discordo (1) (2) (3) (4) (5) Concordo

Achei cansativo e às vezes ficava com preguiça.
Discordo (1) (2) (3) (4) (5) Concordo

De uma maneira geral, qual a nota você dá para a sua experiência participando do workshop?

Ruim (1) (2) (3) (4) (5) (6) (7) (8) (9) (10) Excelente

Alguma sugestão de como poderia melhorar?

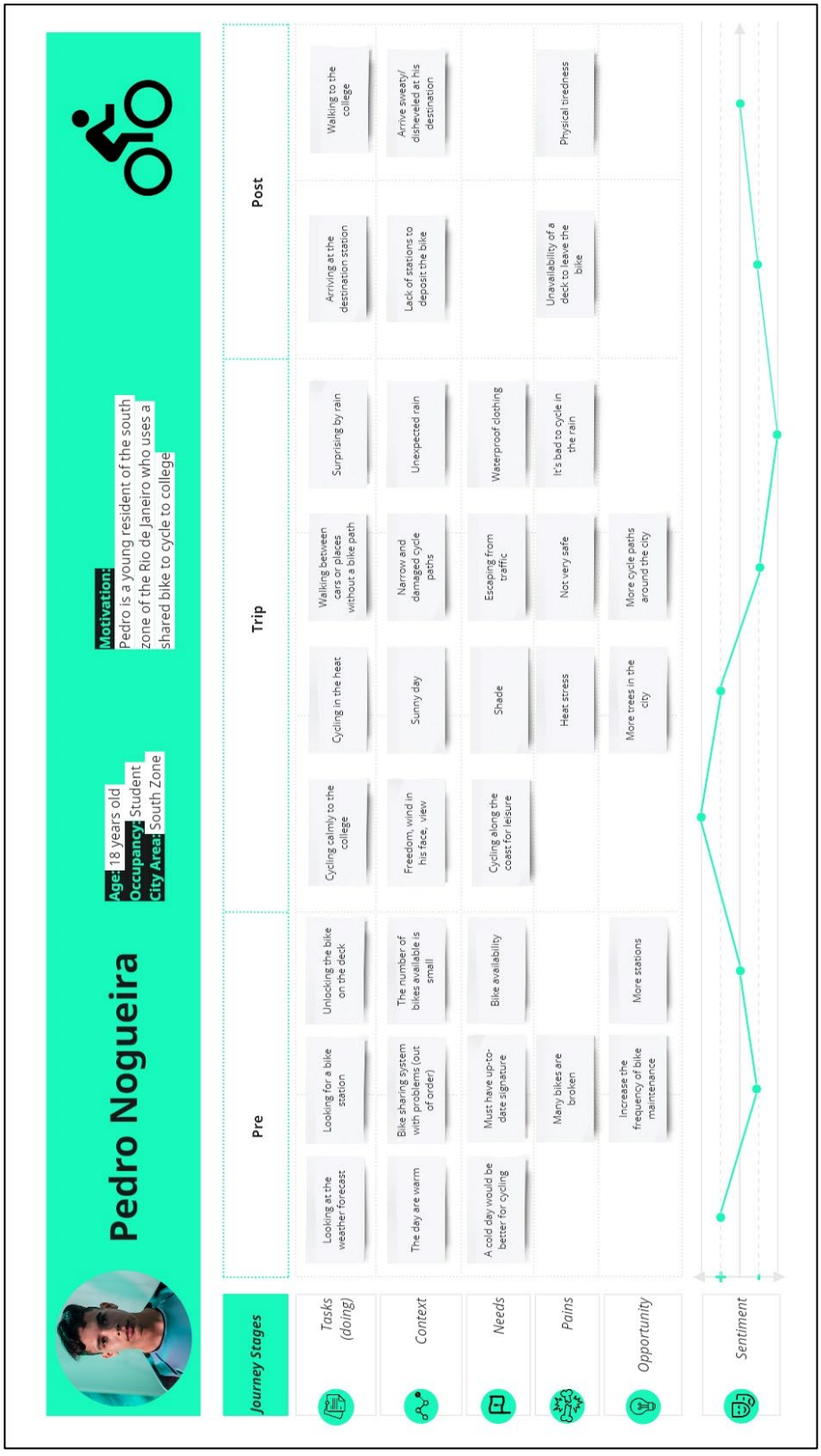
_____

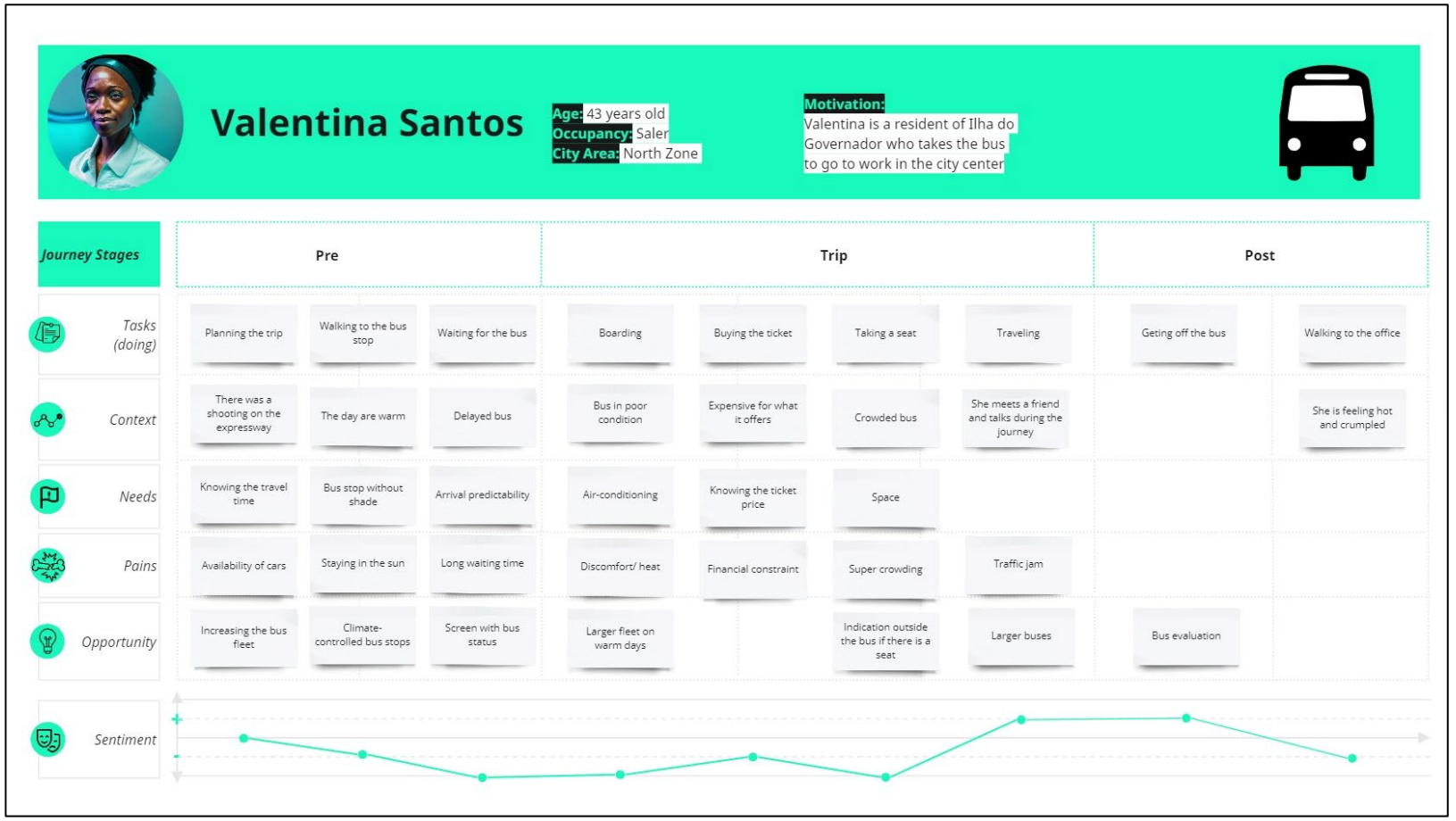
_____

_____

_____

Appendix N: User journeys



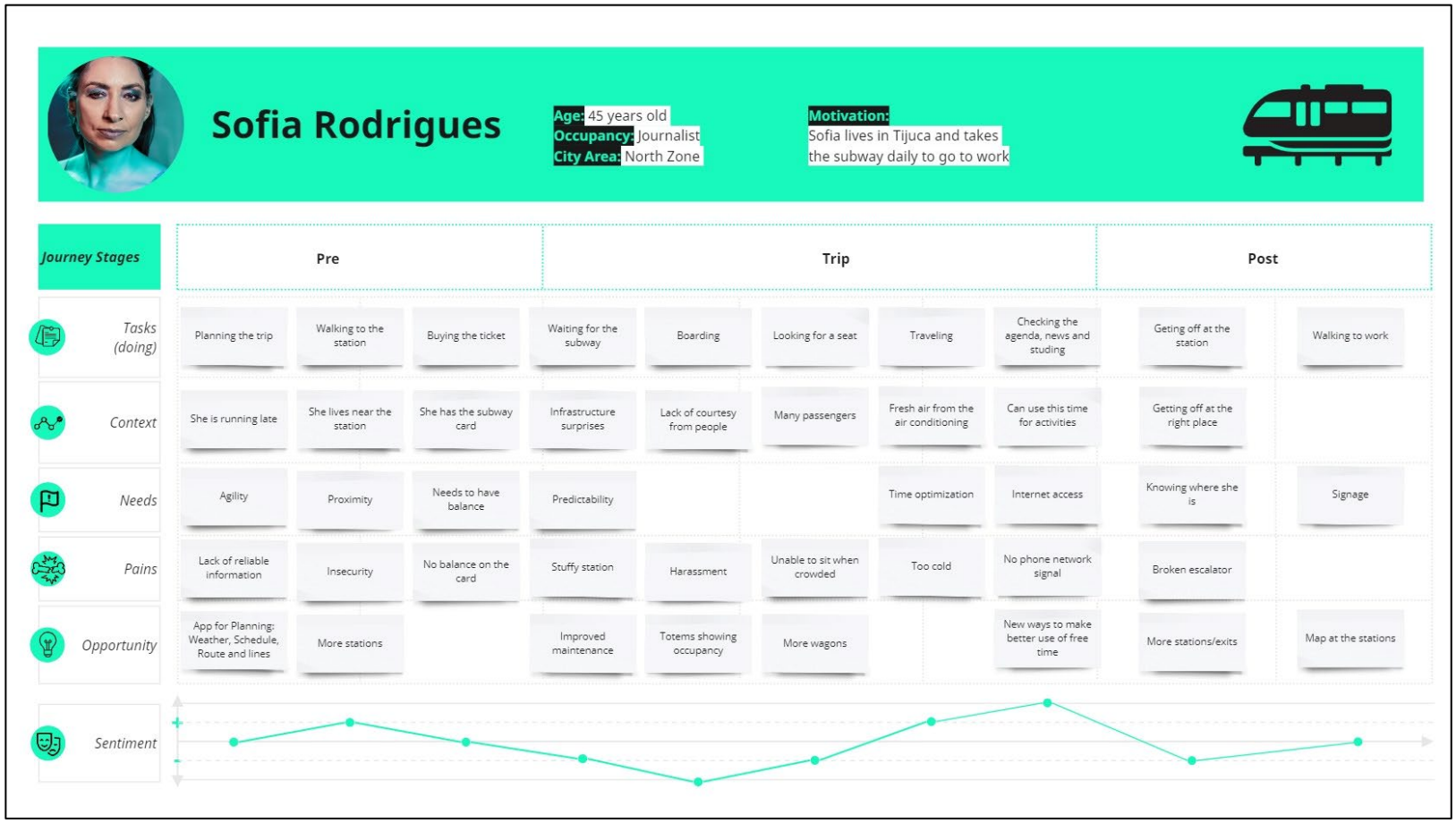

Valentina Santos
Age: 43 years old
Occupancy: Saler
City Area: North Zone
Motivation:
Valentina is a resident of Ilha do Governador who takes the bus to go to work in the city center
Journey Stages
Pre
Trip
Post
Tasks (doing)
Planning the trip
Walking to the bus stop
Waiting for the bus
Boarding
Buying the ticket
Taking a seat
Traveling
Geting off the bus
Walking to the office
Context
There was a shooting on the expressway
The day are warm
Delayed bus
Bus in poor condition
Expensive for what it offers
Crowded bus
She meets a friend and talks during the journey
She is feeling hot and crumpled
Needs
Knowing the travel time
Bus stop without shade
Arrival predictability
Air-conditioning
Knowing the ticket price
Space
Pains
Availability of cars
Staying in the sun
Long waiting time
Discomfort/ heat
Financial constraint
Super crowding
Traffic jam
Opportunity
Increasing the bus fleet
Climate-controlled bus stops
Screen with bus status
Larger fleet on warm days
Indication outside the bus if there is a seat
Larger buses
Bus evaluation
Sentiment
+
-

André Almeida

Age: 70 years old
Occupancy: Engineer
City Area: Niterói

Motivation:
André lives in Niterói, and when the bridge is congested, he takes the ferry to go to work

Journey Stages	Pre			Trip				Post	
Tasks (doing)	Checking the traffic	Checking the schedule for the next ferry	Buying the ticket	Waiting for the departure	Boarding	Taking a seat	Traveling	Exiting the ferry	Taking another mode of transportation
Context	Traffic jam on the bridge	Large time gap between ferries	Increase in ticket price	Rainy weather	Very crowded in peak hours	Enjoys the scenery	Side rain - wind	Everyone leaving at the same station at the same time	Multi-modal journey
Needs	Commute Rio-Niteroi	Reduce the time between ferries	Reduce the ticket price	Protect from rain, sun and wind		Comfortable and ergonomic environment		More organization	Continuing to the destination
Pains	Traffic		Huge queues	Poor infrastructure	Long queue to board the ferry	Stuffy when there is no air conditioning	Discomfort by wind	Takes a long time to exit the ferries	Lack of arrival at the final destination
Opportunity			Buy ticket in advance and online		Capacity forecast	Air conditioning in all ferries	Installing awnings to protect from rain	More ferry boarding and disembarking points	Better integration with other transportation
Sentiment									


Sofia Rodrigues
Age: 45 years old
Occupancy: Journalist
City Area: North Zone
Motivation:
Sofia lives in Tijuca and takes the subway daily to go to work
Journey Stages
Pre
Trip
Post
Tasks (doing)
Planning the trip
Walking to the station
Buying the ticket
Waiting for the subway
Boarding
Looking for a seat
Traveling
Checking the agenda, news and studing
Geting off at the station
Walking to work
Context
She is running late
She lives near the station
She has the subway card
Infrastructure surprises
Lack of courtesy from people
Many passengers
Fresh air from the air conditioning
Can use this time for activities
Getting off at the right place
Needs
Agility
Proximity
Needs to have balance
Predictability
Time optimization
Internet access
Knowing where she is
Signage
Pains
Lack of reliable information
Insecurity
No balance on the card
Stuffy station
Harassment
Unable to sit when crowded
Too cold
No phone network signal
Broken escalator
Opportunity
App for Planning: Weather, Schedule, Route and lines
More stations
Improved maintenance
Totems showing occupancy
More wagons
New ways to make better use of free time
More stations/exits
Map at the stations
Sentiment