

**MESTRADO**

**MULTIMÉDIA - ESPECIALIZAÇÃO EM CULTURA E ARTES**

# **MOBILE APPLICATIONS FOR E-SCOOTER NAVIGATION: A MULTIMEDIA DESIGN APPROACH**

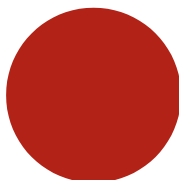
Mingailė Aušrinė Maželytė

**M**

**2024**

FACULDADES PARTICIPANTES:

**FACULDADE DE ENGENHARIA  
FACULDADE DE BELAS ARTES  
FACULDADE DE CIÊNCIAS  
FACULDADE DE ECONOMIA  
FACULDADE DE LETRAS**



# **Mobile Applications for E-Scooter Navigation: A Multimedia Design Approach**

**Mingailė Aušrinė Maželytė**

Mestrado em Multimédia da Universidade do Porto

Orientador: Luciano Moreira

Coorientador: Bruno Cardoso, Sara Ferreira

Junho de 2024

© Autor, 2024

# **Mobile Applications for E-Scooter Navigation: A Multimedia Design Approach**

**Mingailė Aušrinė Maželytė**

Mestrado em Multimédia da Universidade do Porto

Aprovado em provas públicas pelo Júri:

Presidente: Professor Doutor Bruno Sérgio Gonçalves Giesteira, Professor Auxiliar,  
Faculdade de Belas Artes da Universidade do Porto

Vogal Externo: Professor Doutor Marco Boffi, Assistant Professor, Università degli Studi  
di Milano Statale

Orientador: Doutor Luciano José Santos Reis Moreira, Doutorado de Nível Inicial,  
Faculdade de Letras da Universidade do Porto



# Resumo

Esta tese explora a integração de princípios de design multimédia no desenvolvimento de uma aplicação de navegação móvel especificamente concebida para utilizadores de trotinetes eléctricas. Dado que as trotinetes eléctricas são cada vez mais utilizadas nas cidades como meio de transporte flexível e amigo do ambiente, há uma grande necessidade de aumentar a sua usabilidade e segurança através de soluções de navegação inovadoras. Este estudo utiliza uma metodologia abrangente que combina grupos de discussão, entrevistas a especialistas e prototipagem para responder a esta necessidade.

A investigação foi iniciada com grupos de discussão para recolher informações directas dos utilizadores sobre as preferências de navegação das trotinetes electrónicas e as preocupações de segurança. Em seguida, foram realizadas entrevistas com profissionais da micromobilidade e dos transportes urbanos para incorporar conhecimentos específicos do sector no desenvolvimento da aplicação. As informações obtidas a partir destes estudos qualitativos serviram de base à conceção e ao teste iterativo de um protótipo funcional de navegação em trotinetes electrónicas, desenvolvido com o Figma devido às suas fortes capacidades interactivas.

A análise dos dados destas metodologias revelou os principais requisitos e preferências de conceção, que foram fundamentais para a fase de desenvolvimento do protótipo. O protótipo final demonstrou um design centrado no utilizador que não só dá prioridade à segurança do utilizador, como também melhora a experiência geral do utilizador através de uma interface intuitiva e de uma funcionalidade prática. Este estudo não só contribui para o conhecimento académico em multimédia e design da experiência do utilizador, mas também fornece implicações práticas para o desenvolvimento de ferramentas de navegação que podem integrar-se perfeitamente no cenário da micromobilidade urbana.

Combinando eficazmente quadros teóricos com investigação empírica, esta tese apresenta uma exploração detalhada de como o design multimédia pode ser utilizado para melhorar a segurança e a eficiência dos sistemas de navegação das trotinetes electrónicas, permitindo, em última análise, uma melhor integração das trotinetes electrónicas no ambiente dos transportes urbanos.



# Abstract

This thesis explores the integration of multimedia design principles in the development of a mobile navigation application specifically tailored for e-scooter users. As e-scooters are increasingly used in cities as a flexible and environmentally friendly means of transport, there is a strong need to increase their usability and safety through innovative navigation solutions. This study employs a comprehensive methodology combining focus groups, expert interviews, and prototyping to address this need.

The research was initiated with focus groups to gather direct user insights on e-scooter navigation preferences and safety concerns. Following this, expert interviews were conducted with professionals in micromobility and urban transport to incorporate industry-specific insights into the application's development. The insights garnered from these qualitative studies informed the design and iterative testing of a functional e-scooter navigation prototype, developed using Figma for its strong interactive capabilities.

Analysis of the data from these methodologies revealed key design requirements and preferences, which were instrumental in the prototype development phase. The final prototype demonstrated a user-centered design that not only prioritizes user safety but also enhances the overall user experience through intuitive interface and practical functionality. This study not only contributes to academic knowledge in multimedia and user experience design but also provides practical implications for the development of navigation tools that can integrate seamlessly into the urban micromobility landscape.

By effectively combining theoretical frameworks with empirical research, this thesis presents a detailed exploration of how multimedia design can be used to improve the safety and efficiency of e-scooter navigation systems, ultimately enabling better integration of e-scooters into the urban transportation environment.

# Table of Contents

|                                                                           |     |
|---------------------------------------------------------------------------|-----|
| Introduction .....                                                        | 11  |
| Context .....                                                             | 11  |
| 1. State of The Art .....                                                 | 15  |
| 1.1. Multimedia Design.....                                               | 15  |
| 1.2. Mobile Navigation Applications .....                                 | 19  |
| 1.2.1. Google Maps .....                                                  | 20  |
| 1.2.2. Waze .....                                                         | 22  |
| 1.3. E-Scooters .....                                                     | 25  |
| 1.3.1. Shared economy, smart cities and e-scooter sharing platforms ..... | 26  |
| Research Questions: .....                                                 | 30  |
| 2. Methods.....                                                           | 32  |
| 2.1. Focus Groups and Expert Interviews .....                             | 32  |
| 2.1.1. Participants Selection .....                                       | 33  |
| 2.1.2. Materials and procedures .....                                     | 35  |
| 2.2. Prototype Development.....                                           | 38  |
| 2.2.1. Design process .....                                               | 38  |
| 2.2.2. Testing and feedback .....                                         | 40  |
| 3. Results .....                                                          | 41  |
| 3.1. Focus Groups .....                                                   | 41  |
| 3.2. Expert Interviews .....                                              | 43  |
| 3.3. Prototype .....                                                      | 44  |
| 4. Discussion .....                                                       | 48  |
| 5. Conclusion.....                                                        | 51  |
| 6. Bibliography.....                                                      | 53  |
| ANNEX A – Script for Focus Groups .....                                   | 58  |
| ANNEX B – Script for the Expert Interview with Expert #1 .....            | 61  |
| ANNEX C – Script for the Expert Interview with Expert #2 .....            | 63  |
| ANNEX D – Consent Form for Focus Group participants .....                 | 65  |
| ANNEX E – Focus group transcript #1 .....                                 | 67  |
| ANNEX F – Focus group transcript #2.....                                  | 76  |
| ANNEX G – Interview with Expert #1 Transcript.....                        | 86  |
| ANNEX H – Interview with Expert #2 Transcript.....                        | 95  |
| ANNEX I - Figma Prototype .....                                           | 103 |

# Figure List

**Figure 1** Google Maps User Interface (UI) ..... 21

**Figure 2** Waze User Interface (UI) ..... 23

**Figure 3** Bolt User Interface ..... 29

**Figure 4.** Lime User Interface ..... 30

**Figure 5** Sketches of application designs by first focus group’s participants ..... 39

**Figure 6** First version of prototype, done on Figma ..... 40

**Figure 7** Hazard alerts in the prototype ..... 45

**Figure 8** Travel mode in the prototype ..... 46

# Table List

**Table 1** Participant Characteristics ..... 34

## **Introduction**

In this digital age, where the pace of life is accelerating, the integration of technology into our daily lives has become more significant, especially when it comes to navigating the urban environment. This is especially visible in the development of mobile navigation applications, as these tools aim to aid and simplify the process of moving around cities. These applications are usually designed to be intuitive and minimally distracting and respond to the challenges that are posed by the density and pace of modern urban life. As urban environments continue to evolve, the need for innovative and sustainable mobility solutions becomes increasingly critical. In this context, e-scooters have emerged as a popular mode of transportation, offering an agile alternative for city commuting. However, the rise in e-scooter usage presents new challenges, particularly in terms of navigation and safety. Traditional mobile navigation apps, primarily designed for vehicles and pedestrians, often fall short in addressing the unique requirements of e-scooter users. This discrepancy highlights the necessity for a dedicated navigation system that not only enhances the safety of e-scooter riders but also integrates seamlessly with the urban traffic ecosystem.

## **Context**

The surge in e-scooter usage across global cities has highlighted a gap in the existing navigation systems, which are predominantly designed for cars and pedestrian traffic. The unique dynamics of e-scooters, such as speed and the need for precise maneuvering, demand a dedicated navigation system that can enhance safety and operational efficiency. This thesis explores the potential of multimedia design principles in developing a specialized navigation app for e-scooter users, aiming to contribute not only to academic knowledge but also to practical applications in urban mobility.

The widespread adoption of e-scooters in urban environments has unveiled significant gaps in existing mobile navigation systems, which are primarily designed for more traditional forms of transportation like cars and walking. These gaps manifest particularly in the safety concerns and navigational inefficiencies faced by e-scooter users, who require real-time data and specific route information tailored to the unique dynamics of e-scooter travel.

Research questions:

1. What are the key usability and safety features that e-scooter users prioritize in mobile navigation apps?

2. What is the perceived significance of dedicated e-scooter navigation apps on urban traffic flow and public safety?
3. Based on prior research and expert feedback, which prototype design features are most effective in enhancing the safety and navigational efficiency of e-scooter users in urban environments?

Objectives:

- Develop a detailed understanding of e-scooter user needs and preferences. This involves conducting empirical research through user focus groups to gather data on what features e-scooter users find most beneficial for safety and usability.
- Conduct in-depth expert interviews to refine app functionality. Engage with urban mobility experts and technology specialists through detailed interviews to gather advanced insights into the integration and optimization of navigation systems within urban environments.
- Prototype development and iterative feedback evaluation. Design and develop a prototype of the e-scooter navigation app, then conduct iterative testing sessions with users to gather feedback.

This study employs a mixed-methods approach, combining qualitative and design-based research. Focus groups and expert interviews provide insights into user preferences and expert recommendations, which inform the iterative design of the app prototype. This process includes stages of design, testing, feedback, and refinement to ensure the end product is both theoretically functional in an urban environment, while also being user-centered.

The dissertation is structured into five chapters:

1. State of the Art: Reviews existing literature on multimedia design, mobile navigation applications, and e-scooter mobility. It begins by delving into the role of multimedia design in shaping user interaction and engagement, demonstrating its importance in enhancing the utility and appeal of digital interfaces. The chapter then transitions into a detailed examination of mobile navigation applications, focusing on how they influence urban mobility. The focus then shifts to e-scooter apps and integrate with e-scooter usage,

highlighting the unique requirements of these platforms compared to traditional navigation systems. This chapter laid the foundation for future chapters, which will address the research questions, guide the methodological framework and frame the implications of the findings.

2. **Methods:** Details the research methods used, including focus groups, expert interviews, and prototype development. Focus groups were conducted to capture diverse user experiences and preferences regarding e-scooter navigation. In-depth interviews with experts in urban mobility and micromobility provided insights into the broader implications of e-scooter integration into urban transport systems. The chapter also describes iterative design and testing of the e-scooter app prototype, involving users in the testing phase to refine the app based on feedback. This methodological framework ensures a strong analysis, supporting the development of a user-centered navigation solution that addresses the specific needs of e-scooter riders in urban environments.
3. **Results:** Presents a detailed analysis of the data collected through focus groups, expert interviews and prototype testing. This chapter explains how the feedback from e-scooter users and insights from micromobility experts have directly influenced the design and functionality of the prototype of the e-scooter navigation app. The chapter also discusses the outcomes of the prototype testing sessions, revealing how users interacted with the app, their satisfaction levels, and their suggestions for improvements. These results validate the effectiveness of participatory design approach used in the study and outline how the prototype has evolved in response to user feedback, thereby enhancing its usability and relevance for urban e-scooter riders.
4. **Discussion:** Discusses the findings from the Results chapter withing the broader context of existing literature discussed in the State of the Art chapter. This chapter synthesizes the insights gained from user feedback, expert interviews and prototype testing, exploring how these findings interact with established theories and previous research on e-scooter mobility and navigation technologies. This chapter also identifies gaps that emerged during the research and suggest areas for future investigation.
5. **Conclusion:** Summarizes the research, reaffirming how the study addressed the initial research questions and achieved its objectives. It provides a concise summary of the insights gained from the focus groups, expert interviews and prototype evaluation. The chapter highlights the practical implication of the research for urban mobility, particularly in enhancing safety and efficiency for e-scooter users through tailored navigation solutions. The conclusion outlines future research directions, proposing further studies to refine and

expand upon the prototype's capabilities and to explore new aspects of e-scooter mobility that emerged as important during the research.

# **1. State of The Art**

## **1.1. Multimedia Design**

As visual and interactive elements come together in the dynamic world of multimedia, design plays a crucial role in forming our digital experiences. Beyond its aesthetic appeal, design holds fundamental value in shaping how we perceive, engage with, and derive meaning from digital content (Soegaard, 2018). Whether it be the seamless flow of a website, the intuitive navigation of an app, or the immersive ambiance of a multimedia presentation, thoughtful design not only enhances user satisfaction but also serves as a conduit for effective communication. Multimedia design is a dynamic and interdisciplinary field that blends visual, auditory, and interactive elements to create engaging experiences across various platforms (Costello, 2023). This design approach leverages graphics, text, audio, video and animation to communicate messages effectively and enhance user engagement.

Historically, graphic design and multimedia design have been utilized to communicate knowledge amongst humans across generations since the early ages. Visual representations have been recognized by numerous scientists as tools to aid cognitive comprehension in a variety of scientific domains (Zallio, 2021). As a result, visual representations are becoming increasingly crucial in scientific communication and teaching. A study in Switzerland, that was investigating the impact of graphical visualization in STEM (STEM – Science, Technology, Engineering and Mathematics) research papers showed compelling results, as the visual representations helped scientists share their research findings in a more captivating, visually clear and effective way, reaching wider audience across disciplines. (Zallio, 2021). There are also examples of the impacts of graphic design in other various fields, such as food and other kinds of packaging. For example, packaging and visuals can matter in how we perceive the quality in a product. Various characteristics such as color, amount of print and imagery and other visual elements can impact consumers and their choices or opinions regarding the product. (Gjerde, 2022). Essentially, graphic design and its components have an impact on a wide range of sectors, including science and product design, where they are utilized as powerful instruments to help audiences quickly understand information. In addition to adding to the visual appeal, graphic design creates a dynamic means of communicating difficult ideas in a way that is easy to understand and quickly absorbs. Graphic design becomes a common language, breaking down barriers and helping people understand and interact with information more effectively, whether it is used to explain complex scientific facts or to improve the way product information is presented. In essence, the principles and practices of graphic and multimedia design go beyond aesthetics

(Gjerde, 2022). They embody a universal language that transcends cultural and linguistic barriers and allow for a clear and rapid understanding of information in different fields. When applied wisely, design principles can transform even the most complex messages into easily digestible and actionable ones. This transformative power is particularly relevant when designing user interfaces for certain technologies, where the ability to effectively convey important information can ensure safety and positive user experience. By relying on time-proven strengths of graphic design, interfaces that can not only inform but also intuitively guide users as they interact with information can be created, ensuring that these tools fit almost seamlessly into the structure of daily life.

Messages presented in a multimedia format, such as an animation or video, can have an advantage over printed messages that are just plain text (Occa and Morgan, 2022). Multimedia messages can include a variety of medium types, such as video, animation, images and audio. They also have qualities that can be effective in producing knowledge, changing attitude and behavior. By combining visuals and verbal elements, multimedia messages help individuals to better connect mental models (Occa and Morgan, 2022). Second, these connections may require less cognitive resources compared to the resources consumed while being exposed to static messages. Thirdly, the amount of information presented through both the visual and auditorial stimuli allows individuals to learn and comprehend messages more easily and successfully.

When it comes to entertainment, strategic use of multimedia elements, such as colors and display of content can help in maintaining user attention and enhancing the visual appeal. (Kuo et al., 2022). The use of various forms of media, such as text, audio, video, and animation, not only entertains, but also help communicate information effectively, making it accessible and engaging to all types of users. Interactive elements, such as customizable color modes and adaptive content, also play a part in improving the overall user experience (Kuo et al., 2022). Combining design elements with user expectations and preferences increases satisfaction and promotes deeper engagement with the content. This focus on aesthetic and functional aspects in app design not only meets the diverse needs of users – ranging from information to entertainment – but also fosters a deeper emotional connection to the content, thereby increasing user satisfaction and interaction with digital entertainment platforms. The same principles can also be seen in the field of marketing and designing advertisements. Marketing specialists use multimedia design to create impactful narratives which connect with users while encouraging brand engagement. By making the advertisements more visually appealing, such as using colors and dynamic content to captivate attention, marketers can engage users in a more emotional level (Zhang and Hong, 2022). Multimedia design can also help transform advertisements from static to dynamic by integrating interactive features. Mobile media technologies, such as QR codes or augmented reality elements

not only draws users in but also encourages them to interact with the brand, enhancing user engagement and increasing the narrative impact. (Zhang and Hong, 2022). Additionally, personalization by tailoring ads to the user's preference and behaviors makes sure that the content is relevant and interesting to the user.

Each day, humans process a lot of information to accomplish various goals and to successfully navigate through the environment. In some cases, a poor match between man-made equipment (or the environment) and the human information processing system can lead to misperceptions and memory failures. (Costello, 2023). However, while these applications are meant to act as assistants and avoid distracting the user too much, it can still contribute to cognitive overload, and they inevitably demand the user's attention alongside their primary task. This can lead to the user failing to process the information correctly and efficiently, leading to a decreased performance in both the task and the application. That's why the overall rule of thumb is to limit the users' working memory during task performance and minimize confusability by keeping the design minimal and highlighting only the most important information in the most comprehensive way possible (Costello, 2023).

Since emotions are a necessary part of life and they can affect how a user feels, behaves and thinks, designers started looking into emotional design and how it can evoke a positive emotion from the users, thereby enhancing their overall experience and connection with the product. Emotional design refers to an approach in design practice where the primary goal is to elicit specific emotions from the user in order to enhance their overall experience and connection with a product. (Paduraru, 2022). This design integrates aspects of psychology with traditional design principles to create products that can resonate with users on an emotional level. It can create experiences that are more memorable, enjoyable, and effective in communicating brand values and messages. There are three different levels of processing emotional design, which are all equally important in order to create the most efficient version of any design. (Jeon, 2017). The first level is visceral, and it is the fastest form of processing information, meaning that it is all about immediate emotional impact, physical features and perception (Norman, 2007). The second level is behavioral, which is all about human-centered design. This means that instead of looks, the user must feel satisfied with the product. The third level is reflective, and it focuses on giving the product meaning and significance (Norman, 2007). So, by acknowledging these three levels of processing emotional design, a designer can significantly improve their user experience and interface by making it visually appealing, easy and satisfying to use and giving the user a reason to indulge in it (Jeon, 2017). However, while there is evidence that the use of emotional design can be effective and improve user experience, it can still raise ethical and integrity issues in certain

contexts. Emotional design is often used in advertising a marketing to elicit specific reactions from users, usually to persuade or influence purchase decisions. But, in fields where the primary objective is not to sell a product, but rather to provide critical information or services, such as in healthcare or safety applications, the use of emotional design could be considered inappropriate or even unethical (Makanadar, 2024). In these settings, the ethical implementation of emotional design must shift away from persuasion tactics and instead focus on fostering a sense of trust and reliability for the user.

Instead of emotional design, the focus should be on minimal design principles that prioritize reducing cognitive load, ensuring that users can make quick and accurate decisions without being overwhelmed by unnecessary information or emotional stimuli. Minimal design, often referred to as minimalist design, is a design philosophy that emphasizes simplicity and the use of essential elements in its approach (Costello, 2023). It operates under the principle of “less is more,” focusing on the essentials to create a clean, uncluttered user interface. This approach is not only more ethical, but also more practical in contexts where users must process information efficiently and safely. By simplifying the design and presenting information in a clear and concise way, the app acts as a support to the user’s main tasks without distracting the user with unnecessary design elements or emotional charged content (Costello, 2023). In this regard, the minimal design does not manipulate, but rather empowers users by providing the tools they need to perform effectively and confidently. It aligns the purpose of the app with the user’s need for simple and reliable functionality by removing any elements that do not serve this purpose.

The impact of multimedia design has a noticeable effect on a wide range of fields, proving its importance as an essential element in the making of digital experiences both now and in the future. These techniques will continue to advance as technology progresses, shaping our experience with how we interact, learn, and engage with digital content (Costello, 2023). Mobile apps are a realm full of multimedia design trends and methods that impact our daily interactions. Within this dynamic landscape, each interface, animation, and interactive element contributes to a narrative in which design is more than just an aesthetic choice, but an essential component of the user experience. Beyond an app's basic functioning, the aesthetics and visual appeal created by multimedia design play an important role in creating the overall user experience (Costello, 2023). A well-designed interface not only simplifies navigation, but also conveys a brand's personality and attitude. A study shows that excellent user interfaces facilitate learning and that expressive aesthetic design elements also encourage curiosity to interact with the subject (Ruf et. al, 2022). Users are drawn to visually appealing components, such as vibrant color schemes, smooth animations, and interactive features, which provide a sense of immersion and delight (Ruf et. al,

2022). Good design is more than simply aesthetically pleasing; it also improves usability, making the app more intuitive and user-friendly. The impact is not only immediate, but also long-term, because a well-designed mobile application develops positive user perceptions, stimulates prolonged usage, and, eventually, builds a devoted user base (Ruf et. al, 2022).

## **1.2. Mobile Navigation Applications**

Moving on from the overarching implications of multimedia design in various general contexts and interfaces, the focus shifts on its specific impact in the context of on-the-go navigation applications. Mobile navigation applications represent a pivotal intersection of multimedia technology and practical utility, reshaping how individuals interact with urban environments (Ruginski et al., 2022). In a multimedia perspective, these applications integrate diverse media elements – visual maps, audio instructions and tactile feedback through vibrations – to create a comprehensive user experience that enhances spatial awareness and decision-making on the go. The effectiveness of these apps stems not only from their ability to guide users from point A to point B but also from their dynamic presentation of information (Ruginski et al., 2022). This includes real-time traffic updates, hazard alerts, and route optimization, all displayed through engaging graphical interfaces. The inclusion of multimedia elements makes navigation intuitive and accessible, catering to a broad spectrum of users with varying levels of technical proficiency and sensory preferences. As such, mobile navigation apps embody the fusion of technology, design, and user-centric interaction, highlighting the transformative power of multimedia in everyday applications.

On-the-go apps, or navigation applications, like Waze and Google Maps, are digital tools designed to aid users in real-time navigation and route planning. These apps provide turn-by-turn directions, traffic updates, and alternative routes to help users reach their destinations efficiently (Cybulski, 2020). Beyond navigation, they often include features like locating gas stations, restaurants, and parking spaces, enhancing the travel experience. Primarily used while driving, walking, or cycling, they balance interactive engagement with safety, offering both visual and audio guidance to accommodate the user's focus on their primary activity (Cybulski, 2020). To better understand how and why these applications work, it is necessary to explore their user interface (UI). User interface design is crucial in mobile navigation apps since it directly affects usability and user satisfaction (Soegaard, 2018). The interface must be simple and uncluttered,

minimizing distractions while increasing the user's ability to understand and act on information quickly (Costello, 2023). This is especially useful in situations where quick decision-making is crucial, such as driving or navigating through busy streets and traffic. To delve deeper into user interface design, it's essential to consider the layout of on-screen elements, the choice of colors, typography, and how these factors contribute to the overall navigational experience (Cybulski, 2020). High contrast colors, for example, improve visibility in different lighting conditions, and larger fonts make it easier to read directions quickly (Costello, 2023). Additionally, the way information is layered and presented greatly influences how intuitively users can interact with the app. Gesture-based controls and voice commands also play a crucial role, enabling hands-free operation, which is especially important for activities like driving (Cybulski, 2020). Understanding user behavior and preferences is also key to optimizing these applications. By analyzing usage patterns and gathering feedback, developers can continuously refine UI elements to better meet the needs of diverse user groups.

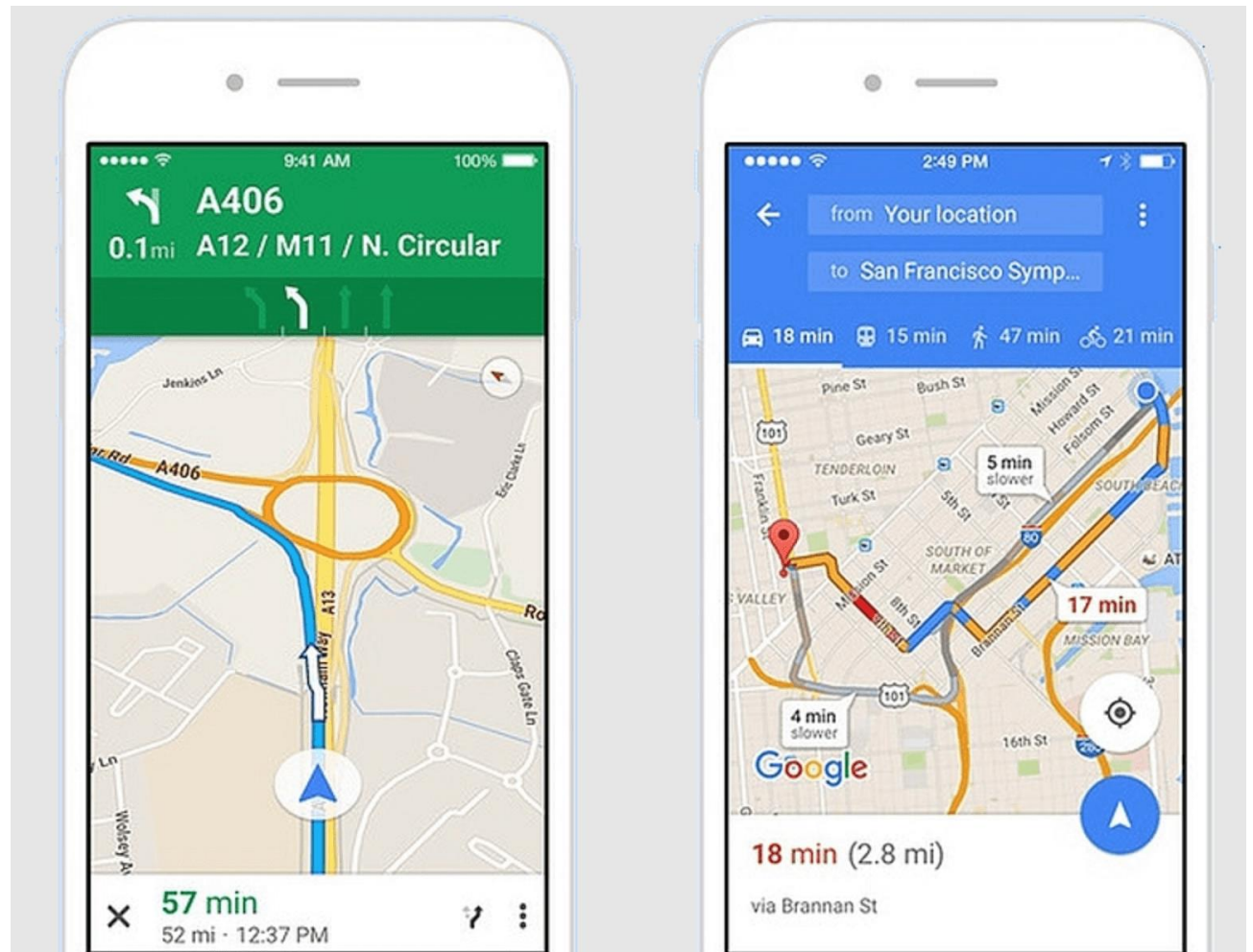
### **1.2.1. Google Maps**

When thinking of mobile navigation apps primarily used on-the-go, Google Maps is the one that usually comes to mind. Google Maps is a standout example of how multimedia technology can be effectively integrated into mobile navigation apps, making complex urban navigation easier. This app uses a mix of visual, auditory, and tactile elements to create a strong user experience, enhancing spatial awareness and aiding decision-making on the go (Cybulski, 2020).

The app offers a highly intuitive and detailed interface with various map layers, including satellite imagery, street views, and real-time traffic conditions (**Figure 1**). These elements are color-coded – blue for clear traffic, yellow for moderate, and red for heavy – so users can quickly assess and adjust their routes. This visual approach not only simplifies map reading but also significantly improves planning efficiency.

**Figure 1**

*Google Maps User Interface (UI)*



Google Maps also provide clear, real-time audio instructions, which are crucial for drivers. This hands-free feature enhances driving safety by allowing users to focus on the road while receiving necessary navigation guidance (Cybulski, 2020). It exemplifies how auditory feedback can be effectively used to boost user safety and convenience in multimedia applications. Although not as prominent, haptic feedback offers an additional interaction layer, alerting users to important notifications like upcoming turns or route changes without needing to look at the screen.

Google Maps excels in presenting dynamic and predictive information, such as real-time traffic updates and route suggestions based on historical traffic patterns. These features optimize routing and travel time, showing the app's ability to adapt to real-world conditions and provide tailored advice. This dynamic data presentation is essential for maintaining the relevance and effectiveness of navigation apps in urban settings.

The design of Google Maps is also user-centric, meaning that it comes with numerous customization options that enhance its utility (Cybulski, 2020). Users can save frequently visited locations, tailor notifications, and choose preferred routes or transport modes, making the app highly adaptable to individual needs. Accessibility features like voice navigation and high-contrast modes for those who may have visual impairments further demonstrate Google Maps' commitment to inclusivity. Additionally, Google Maps integrates seamlessly with other Google services, enhancing its functionality. For instance, integration with Google Street View provides immersive, street-level imagery, allowing users to familiarize themselves with new destinations before arrival. Other functions, like including local business information, such as reviews and operational hours, directly within the map interface, further transforms the app from a simple navigation tool into a multifaceted resource for travelers.

However, the app still faces some challenges and drawbacks. Privacy concerns are a major since Google Maps relies on extensive data collection to tailor experiences and boost accuracy in route planning (Fisu et al., 2024). This includes location history, search queries and personal preferences, which raise concerns about user consent and data security (Burney et al., 2018). Another challenge is the app's performance in less densely populated areas. Real-time traffic updates and route advice can be less accurate in these regions because there are fewer data sources (Fisu et al., 2024). This underscores the need for better coverage and more effective data integration.

Nonetheless, Google Maps is a sophisticated and well-designed mobile navigation tool that effectively uses multimedia design principles to improve urban mobility. Its success lies in merging real-time data with user-friendly design elements across visual, auditory and tactile domains, making it indispensable for modern urbanities. As it evolves, balancing enhanced functionality with privacy concerns will be crucial for maintaining its leadership in the navigation app market.

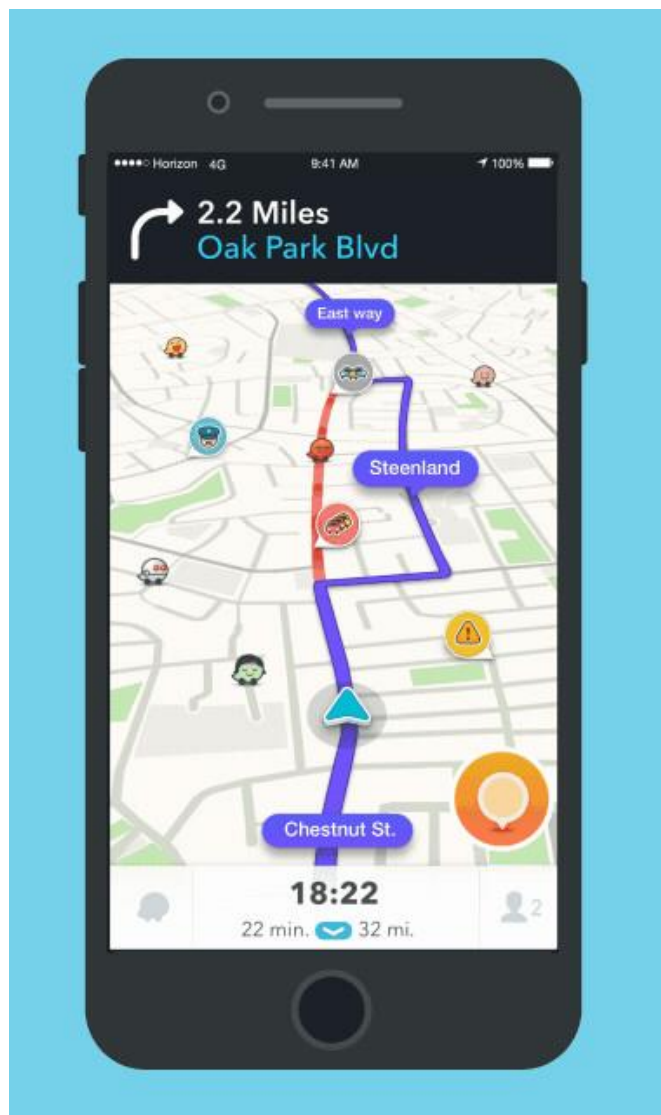
### **1.2.2. Waze**

Another popular navigation application that is worth mentioning is Waze. Waze is a prime example of how multimedia design can enhance mobile navigation apps to tackle the challenges of modern urban travel. Known for its crowd-sourced data approach, Waze heavily relies on user contributions to provide real-time traffic updates and navigation advice (Liu et al., 2024). This approach allows Waze to deliver up-to-the-minute reports on traffic conditions, road hazards, and police presence. This method works exceptionally well in densely populated areas where many users are actively engaged (Liu et al., 2024).

Similar to Google Maps, Waze also features a user-friendly graphical interface that prioritizes clarity and ease of use. The app displays easy-to-read maps with real-time updates on traffic, alerts, and other road events (**Figure 2**). This app also has color-coding to visually represent these updates – blue for smooth traffic, yellow for moderate congestion, and red for heavy traffic – enabling users to quickly grasp the situation at glance.

**Figure 2**

*Waze User Interface (UI)*



Additionally, Waze incorporates various icons and symbols to denote specific road conditions such as construction zones, accidents, and police sightings, further enhancing the map's informational value. The interface is designed to minimize clutter, presenting only the most relevant information, which helps users avoid becoming overwhelmed. This focus on visual simplicity and effectiveness allows drivers to make swift, informed decisions without taking their

attention away from driving for extended periods. Waze's user interface is meticulously designed for quick and easy interaction, allowing users to report conditions with minimal distraction. The interface is intuitive, featuring large buttons and clear icons that facilitate effortless navigation and interaction, even while driving. One of the standout features is the one-tap reporting system, which enables users to quickly report various road conditions such as traffic jams, accidents, hazards, or police sightings. Waze also offers audio navigation to keep users informed without taking their eyes off the road. The audio guidance provides turn-by-turns directions, allowing drivers to rely on auditory cues rather than visual ones. Users are also able to choose from various voices and languages, enhancing personalization and accessibility for non-English speakers or those who prefer specific dialects.

Waze also stands out with its exceptional ability to instantly recalculate routes based on the latest traffic information and user reports. As traffic jams, accidents, road closures, or other unexpected events occur, Waze quickly processes this data and offers alternative routes to help drivers avoid delays. This dynamic adjustment capability not only saves time but also reduces frustration by providing a smooth and efficient driving experience.

Just like Google Maps, Waze also faces similar challenges, especially the ones regarding privacy and data security due to its reliance on user-generated content (Tao et al., 2020). The app's effectiveness also hinges on user density, meaning that in less populated areas, the data may be less accurate and useful (Tao et al., 2020).

In short, Waze successfully applies multimedia design principles in its community-driven approach, real-time responsiveness, and effective use of audio-visual feedback. Its user-friendly interface and integration with other digital services enhance its functionality, making it a valuable tool for drivers worldwide.

In conclusion, mobile navigation applications like Google Maps and Waze have revolutionized how we navigate and interact within cities. These apps are at the cutting edge of multimedia integration, combining visual, auditory, and tactile feedback to create comprehensive user experience that improve spatial awareness and enable real-time decision-making. Google Maps and Waze exemplify the power of multimedia to make navigation user-friendly and efficient. Google Maps provides detailed maps and seamless integration with other services, making it a robust platform for everyday commutes and complex travel plans. Waze, on the other hand, focuses more on the community-driven data to deliver the latest road conditions, which is especially useful in densely populated areas with high user engagement.

### 1.3. E-Scooters

After looking at multimedia design principles and their intricacies in the context of navigation applications, the narrative shifts forward to explore the rise of e-scooters as a dynamic element of urban mobility. As cities embrace these mobile vehicles, e-scooters are at the crossroads of environmental hopes and urban challenges. They are becoming innovative tools to help alleviate transport problems, but at the same time they face challenges of public safety and acceptance (Cloud et al., 2023). The discussion of e-scooters reflects their potential to change the urban landscape by offering sustainable transport options and their current position in the media, which often highlights a range of concerns (Cloud et al., 2023). Understanding the role of e-scooters in the modern urban environment allows for a more detailed analysis of how navigation apps specifically designed for these devices could increase safe use and fit into the concept of shared economy, influencing user behavior and urban transport policy.

Shared mobility and micromobility systems have been rapidly growing in cities around the world for years as part of a shift in mobility patterns and lifestyles (Mitropoulos et al., 2023). E-scooters, whether shared or privately owned, are a potentially environmentally friendly and innovative solution that can help reduce congestion and air pollution, improve community interactions and provide a viable alternative of transport in urban areas (Mitropoulos et al., 2023). In recent years, urban transportation planners have welcomed e-scooters as an alternative to motorized individual transport, with the goal of alleviating transportation-related issues such as congestion, air pollution and noise. With e-scooters adapting into the urban transportation ecosystem, the concept of shared economy has become more integrated with urban transportation. Studies have shown that people engage in e-scooter sharing due to positive aspects such as the temporary nature of use, efficiency, convenience, and entertainment (Nindl, 2022). However, many people openly argue that e-scooters, despite having a relatively low modal share, have been the source of traffic accidents, transportation system disruption, and public space anarchy (Nindl, 2022). The bad reputation of e-scooters, which is currently articulated by the media, where there is approximately one positive e-scooter portrayal for every five negative ones, may influence non-users to be hesitant not only towards their usage but also towards their very existence. There are some factors, such as safety, health, eco-friendliness and cost that even the people who use e-scooters can see as potentially problematic. (Wallgren et al., 2023). According to a study, ever since shared e-scooters were introduced, the number of accidents involving personal injuries in the typical month have increased by 8.2%. (Cloud et al., 2023). Regarding the safety concerns, some of the main issues were infrequent helmet use, alcohol impairment, underage and double riding,

speeding and rider distraction (Janikian et al., 2024). This makes e-scooters a safety hazard not only to the users, but the passerby's who have nothing to do with the e-scooters as well.

So, even though e-scooters are meant to alleviate problems and make transportation more accessible and better for the environment, the public has met them with skepticism and a negative perception, the main issue being safety concerns and the lack of communication about it. As a matter of fact, despite numerous counts of e-scooter research and studies, there is a knowledge gap about e-scooter laws and policies, and moreover there is a difference between how users and non-users perceive e-scooters. While media coverages usually portray e-scooters in a bad light, forcing non-users to perceive e-scooters as a negative thing, users' perceptions are usually more positive compared to non-users (Wallgren et al., 2023). These findings may imply that the media and content that people consume can change their mindset or opinions about certain topics.

When considering the complexity of public perception and accepting e-scooters, the role of effective communication becomes absolutely central. On one hand, we see the challenges that e-scooters face: safety concerns, regulatory uncertainties and distorted media representations that fuel public skepticism (Wallgreen, et al., 2023). On the other hand, the strong impact of multimedia messages become a hope that offers a way to change perceptions and overcome the information divide. This intersection of problem and solution highlights the potential of using multimedia elements – video, animation, images and sound – to not only inform, but also to help the public see e-scooters in a different light. Understanding the dynamics of public perception and the unparalleled ability of using multimedia elements to convey messages to engage and educate, we are ready to delve deeper into strategies that can combine user experience and public acceptance to make e-scooters a welcome, safe and understandable part of urban mobility.

### **1.3.1. Shared economy, smart cities and e-scooter sharing platforms**

Shared economy, also known as the collaborative economy, is a socio-economic system built around the sharing of human and physical resources (Hossain, 2020). It includes the shared creation, production, distribution, trade, and consumption of goods and services by different people and organizations. This model influences technology to facilitate peer-to-peer exchanges, often via an online platform, enhancing access to underutilized assets and reducing the need for ownership (Hossain, 2020).

In the context of urban mobility, the shared economy model has been fundamental in introducing solutions such as e-scooters, which are shared among users who do not own them but access them through a digital platform (Hossain, 2020). The introduction of e-scooters as part of the shared economy has greatly influenced urban transportation by helping reduce the use of

private cars, thus easing city traffic and lowering pollution, which is key to improving city environments (Comi et al., 2024). E-scooters are especially useful for covering short distances and connecting with other forms of public transport, enhancing overall transit effectiveness and accessibility.

But it is important to note that incorporating e-scooters into city setting can come with several challenges. These include ensuring safety on roads shared with other vehicles, providing sufficient parking without overcrowding public spaces, and maintaining the e-scooter fleet to prevent damage and ensure reliability (Comi et al., 2024). Without proper planning and rules, e-scooters could clutter sidewalks and trouble pedestrians, highlighting the need for well-thought-out city policies to manage these issues.

Safety is another major concern, as e-scooters introduce new risks in busy areas. It is crucial to develop specific safety measures and urban designs to protect both e-scooter users and all other road users, including pedestrians and cyclists (Dias et al., 2024). Additionally, while e-scooters are generally more environmentally friendly than cars, it is important to continuously evaluate their overall environmental impact. This includes how they are made and disposed of to ensure that their production and waste processes do not negate their environmental benefits (Dias et al., 2024).

Shared economy does not depend on technology but is given more possibilities and higher reach by it. The growing concept of smart cities is a paradigm where technology is embedded in the urban fabric to simplify operations, increase sustainability and improve quality of life, and e-scooters are an important part of this (Comi et al., 2024). These modes of transport are perfectly in line with the smart city vision and are an efficient alternative to traditional transport. They play an important role in reducing congestion in city centers, cutting carbon emissions and encouraging more active urban living (Comi et al., 2024). It is important to note that the impact of e-scooters goes beyond their physical presence on the streets. It is enhanced by sophisticated multimedia design and the deployment of specific mobile applications. These digital platforms, complemented by GPS tracking, Internet of Things (IoT) integration and user-friendly interfaces, make the use of e-scooters a seamless and rich urban experience (Comi et al., 2024). They not only allow for easy navigation and ridesharing, but also help collect a wealth of data on urban mobility patterns, user preferences and infrastructure efficiency. This data, which is a by-product of the sophisticated multimedia design elements embedded in e-scooter apps, is invaluable for urban planners and policy makers. They provide a comprehensive picture of how e-scooters interact with the urban environment, highlighting areas of high demand, potential safety issues and opportunities for infrastructure improvements. Furthermore, these insights contribute to the

feedback loop, where real-time data helps to continuously improve urban planning strategies, transport networks and environmental policies (Dai et al., 2024).

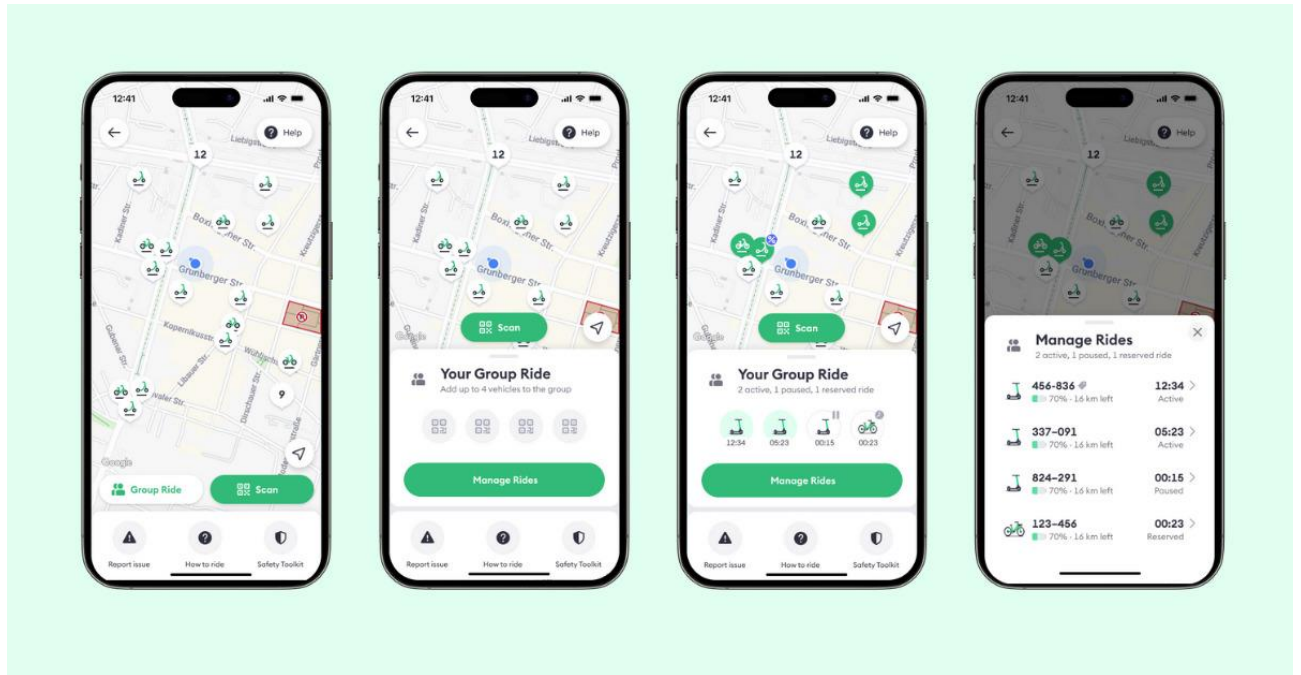
Furthermore, the integration of e-scooters into smart city infrastructure demonstrates a commitment to sustainability and technological innovation (Dai et al., 2024). By using advanced multimedia design techniques to enhance the user interface of e-scooter applications, cities can promote a more attractive and intuitive experience for commuters. This will not only encourage the adoption of micro-mobility solutions, but also increase the overall utility of e-scooters in the urban mobility ecosystem (Dai et al., 2024).

E-scooter sharing platforms have become a fundamental part of urban mobility, offering a fast, affordable, and flexible solution to navigating city environments (Kisa Isik et al., 2023). These platforms allow users to rent e-scooters on-demand using their smartphones, allowing for a convenient way of travel and enhancing urban connectivity and accessibility. Through apps like Bolt and Lime, users can easily locate, unlock, and rent e-scooters. This service model not only alleviates traffic congestion by reducing the number of cars on the road, but also contributes to lowering urban air pollution (Comi et al., 2024). As e-scooter sharing continues to gain popularity, these platforms are becoming integral to the transportation networks of cities worldwide, providing a seamless solution for navigating the complexities of urban environments (Kisa Isik et al., 2023).

Bolt, originally known as Taxify, is an Estonian transportation company that has expanded its offerings beyond traditional ride-hailing to include e-scooter sharing, an increasingly popular component of urban mobility (Branis et al., 2020). Bolt's e-scooter service aims to reshape urban travel dynamics and enhance accessibility within cities. Bolt's e-scooter interface is designed to be intuitive and user-friendly, making it easy for new users to locate and use their shared e-scooter services. The app includes features such as a map to find nearby scooters, the ability to unlock them through a QR code, and straightforward pricing information, enhancing the user experience by providing all the necessary details in a clear and accessible manner (**Figure 3**).

**Figure 3**

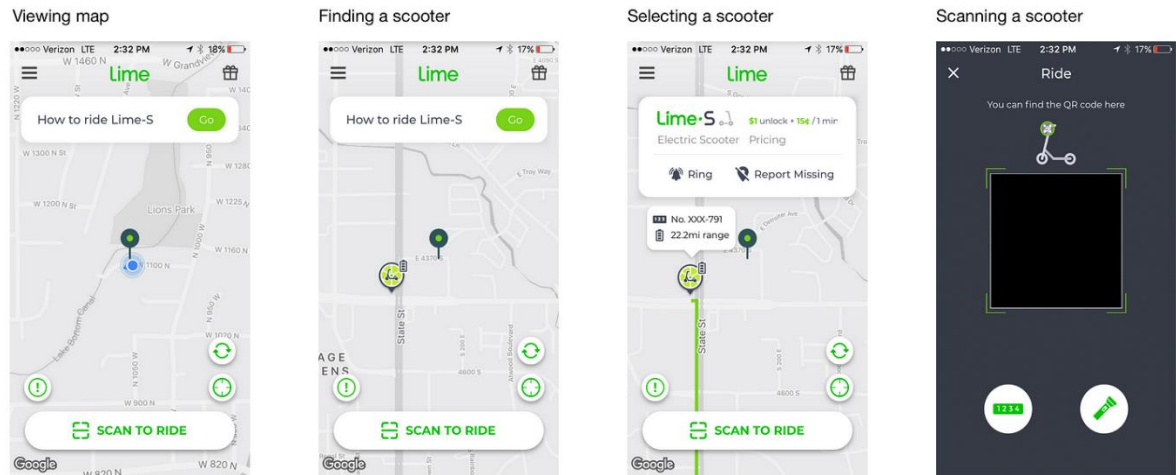
*Bolt User Interface*



Lime is also a prominent player in the micro-mobility industry, offering e-scooter sharing services that aim to alleviate urban congestion and provide sustainable alternatives to traditional transportation methods (Bailey & Sereda, 2020). Launched in 2017, Lime has rapidly expanded its operations to numerous cities worldwide, becoming a key figure in transforming urban mobility. Lime focuses on providing accessible and user-friendly experience through its mobile app, which integrates various features designed to enhance user engagement and convenience (**Figure 4**). Like Bolt, user can easily locate, unlock, and pay for e-scooters using the app, which also provides important information such as battery level and estimated travel distance. Lime continually updates its app and services based on user feedback and technological advancements, ensuring a seamless experience that encourages repeated use.

**Figure 4.**

*Lime User Interface*



Essentially, e-scooters, powered by cutting-edge multimedia design and smart apps, are not just a means of transport. They are part of the evolution of smart cities, driving the creation of more connected, sustainable urban environments that meet the needs of citizens. Because of this relationship between technology and urban planning, e-scooters are helping to create cities that prioritize efficiency, environmental sustainability, and community well-being.

**Research Questions:**

In conclusion, the in-depth analysis of multimedia design principles, mobile navigation applications and the role of e-scooters in urban mobility reveals a critical intersection where enhanced user engagement and improved urban transport efficiency meet. While these topics are well-covered, there is a noticeable gap in the integration of specific user-centric design principles tailored for e-scooter navigation apps withing the broader context of smart city infrastructures. This gap underscores the potential for more focused research on how e-scooter apps can enhance navigational efficiency and safety in urban environments.

To address this, the research questions proposed aim to delve deeper into the user needs and safety concerns specific to e-scooter use.

1. What are the key usability and safety features that e-scooter users prioritize in mobile navigation apps?

This question seeks to identify the key usability and safety features that would be most valued by e-scooter users in a mobile navigation app designed specifically for e-scooters and is fundamental in directing the design features that would enhance user satisfaction.

2. What is the perceived significance of dedicated e-scooter navigation apps on urban traffic flow and public safety?

The second question explores the broader impacts of this app on urban traffic flow and public safety. This aligns with the identified gap by focusing on the integration of e-scooter navigation within urban mobility systems and the potential to improve traffic dynamics.

3. Based on prior research and expert feedback, which prototype design features are most effective in enhancing the safety and navigational efficiency of e-scooter users in urban environments?

The final research question aims to pinpoint which prototype design features most effectively enhance safety and navigational efficiency for e-scooter users in urban settings, informed by prior research and expert feedback. This question bridges the theoretical research with practical design solutions, seeking to help visualize what a mobile navigation app for e-scooters would entail and how it could immediate usability concerns and integrate itself into the urban mobility landscape.

## **2. Methods**

The methodology section of this thesis outlines the research methods used to explore the integration of multimedia design principles in developing a mobile navigation app for e-scooters. The study was designed to gather qualitative and practical insights into user preferences, design efficiencies, and the functional effectiveness of proposed app features. Considering the complexities of designing user-centric mobile applications for dynamic urban mobility, a mix of qualitative methods and developmental testing was deemed most suitable.

The project was iterative, and the prototype was developed along with iterations of e-scooter user focus groups and in-depth interviews with micromobility experts. Each method was selected for its ability to provide detailed and actionable data to inform user-centered design decisions. Focus groups offered diverse user opinions and initial reactions to the app's concept and features, providing a rich qualitative analysis of potential user expectations and concerns (Finch & Lewis, 2003). Expert interviews provided in-depth insights from professionals in transport and micromobility, ensuring the app's development adhered to innovative and safety practices (Finch & Lewis, 2003). Finally, iterative design and testing of an interactive prototype using participatory design principles allowed for user feedback, which is crucial in app development (Noorbergen, 2021).

Combining these methods provided a comprehensive understanding of the factors influencing the acceptance and success of navigation apps in the e-scooter market. The following sections will detail the execution, results, and integration of these methods, laying the groundwork for the findings and recommendations presented in this thesis.

### **2.1. Focus Groups and Expert Interviews**

Before starting on the prototype, it is crucial to gather relevant data and information to figure out the key features and the relevance the app could have on traffic flow and urban mobility. For this reason, a set of focus groups were organized, consisting of users who frequently use e-scooters and can give valuable insights on the necessary key features, meanwhile in-depth interviews were conducted with micromobility experts, to discuss the significance of the app in urban traffic flow. Focus groups were used as a key qualitative research method to gain detailed insights into user experiences and preferences regarding the multimedia design of an e-scooter app. This technique was chosen for its ability to generate rich discussions among users, providing diverse perspectives and a deep understanding of their needs, behaviors, and attitudes toward mobile navigation tools for e-scooters (Finch & Lewis, 2003).

The aim for these focus groups was to explore how potential users interact with e-scooter apps, identify their main concerns and requirements, and assess their reactions to proposed design elements and features. These conversations were crucial in uncovering the contextual usage patterns and expectations users have for such apps, offering valuable insights that guided the following design stages.

To complement the user-centric insights from the focus groups, expert interviews were conducted as a key part of the research methodology. These interviews aimed to leverage the specialized knowledge and professional perspectives of experts in transportation, urban planning, and micromobility. The goal was to deepen the understanding of the technical, social, and infrastructural factors that influence the design and functionality of e-scooter navigation applications (Finch & Lewis, 2003).

Expert interviews were chosen for their ability to provide in-depth and detailed insights that might not be fully captured in focus group discussions. By engaging directly with professionals who have extensive experience and knowledge in relevant fields, the research sought to uncover nuanced insights into the challenges and opportunities within the e-scooter navigation space. Experts were asked to share their perspectives on best practices, industry trends, and potential improvements for e-scooter apps, thus providing a well-grounded understanding that supports the practical application of the research findings.

### **2.1.1. Participants Selection**

Participant selection for the focus groups was carefully designed to target frequent e-scooter users, aiming to gather insights from those most familiar with the practical and navigational challenges of e-scooters. Initially, the recruitment focused on individuals in Portugal, because of their familiarity with the local urban mobility context. However, difficulties in recruiting a sufficient number of participants led to a change of plans. The scope was expanded to include e-scooter users from various countries, including Portugal, Lithuania, The Netherlands, etc. This change broadened the range of cultural and operational insights into e-scooter usage, allowing for the opportunity to consider features that would benefit users that use e-scooters under different regulations and in different urban environments.

Based on the criteria, two sets of focus groups were conducted to explore potential differences in perceptions and experiences based on e-scooter usage patterns. Initially, there was supposed to be only one focus group, but after noticing that it was compromised of only male participants, it seemed only fair to gather another focus group, consisting exclusively of female

participants. This aimed to examine whether gender differences might influence perceptions of safety and usability in e-scooter navigation apps. Participants were also categorized based on their type of e-scooter usage—either shared or personal—and the primary purpose for which they used e-scooters, whether for commuting or entertainment (**Table 1**). This segmentation allowed the study to delve into distinct usage contexts and uncover specific needs and preferences associated with each mode and purpose of e-scooter usage.

**Table 1**

*Participant Characteristics*

| <b>E-scooter usage</b> | <b>Purpose of e-scooter usage</b> | <b>Male</b> | <b>Female</b> | <b>Total</b> |
|------------------------|-----------------------------------|-------------|---------------|--------------|
| Shared e-scooter       | Commute                           | 1           | 1             | 2            |
|                        | Entertainment                     | 1           | 3             | 4            |
| Personal e-scooter     | Commute                           | 2           | 0             | 2            |
|                        | Entertainment                     | 0           | 0             | 0            |

The selection process prioritized achieving a balance that would not only reflect typical user profiles but also provide insights into less common user experiences. This approach was aimed at enriching the understanding of the e-scooter ecosystem, facilitating a comprehensive analysis of how different users interact with e-scooter technology and how these interactions might influence the design and functionality of navigation apps tailored to e-scooter riders.

The initial strategy for selecting experts for the interviews aimed to cover a broad spectrum of disciplines, targeting professionals in user experience, human-computer interaction, and various facets of micromobility and transportation. This multidisciplinary approach was designed to gather a wide range of insights and perspectives to enrich the understanding of developing e-scooter navigation applications.

However, due to time constraints and challenges in securing responses from the targeted experts, the focus was narrowed to specialists in micromobility. This strategic decision allowed for a deeper dive into specific safety concerns and functional aspects of e-scooter use that were highlighted in the focus groups. Focusing on micromobility experts enabled a more detailed discussion on how a navigation app could address and mitigate these concerns through innovative design and technology.

Ultimately, two experts were selected for their specific knowledge and ongoing research in micromobility. Both experts are PhD students with strong backgrounds in the field: one specializes explicitly in e-scooters, and the other has a broader focus on micromobility. This

combination provided a balance of specialized and comprehensive insights. The first expert's focus on e-scooters brought knowledge on current challenges and advancements in e-scooter technologies and usage. In contrast, the second expert, with a broader perspective on micromobility, offered a wider understanding of the urban mobility landscape and its integration with public transportation and urban planning. This expert selection ensured that the interviews were both detailed and comprehensive, covering the critical aspects needed to inform the development of a practical and user-friendly e-scooter navigation application.

### **2.1.2. Materials and procedures**

The script for the focus group revolves around gathering insights from e-scooter users about their experiences, preferences and safety concerns related to using e-scooters and mobile navigation apps, seeking to figure out what the users expect from a mobile navigation app tailored specifically for e-scooters. The script carefully structures a dialogue that not only explores general usage patterns, but also delves into users' emotional and practical responses to specific app features. It has open-ended questions that encourage participants to share personal stories and opinions, as well as initiate discussions between each other. The script begins with a general description of the project and the goal of the application, following with participant introductions and series of questions. The questions are ordered to first understand general usage patterns, like experience and primary reasons, and then specifically probe into the users' interactions with technology while riding e-scooters. This feedback is intended to directly influence the design and features of the app, with the script guiding participants to discuss potential app features that would meet their needs, emphasizing user-centered design principles. The focus group script can be found in the attachments (ANNEX A).

The focus groups were conducted online to accommodate participants from various geographic locations, ensuring convenience and accessibility to everyone involved.

The first focus group, consisting solely of male participants, was held on the platform called Discord. This platform was chosen for its familiarity and accessibility among participants, which helped create a relaxed and open discussion environment. The session lasted about 40 minutes and was divided into two parts. At first, participants were asked general questions about their e-scooter usage, particularly focusing on their experiences and safety concerns. This helped set the context and warm up the discussion, which then moved to more targeted inquiries about addressing

these issues withing the navigation app. This approach allowed for a focused yet comprehensive exploration of the necessary app features and user interface designs to enhance safety and usability.

The second focus group, that consisted of only female participants, was conducted via Google Meet to suit the participants' preferences and technical conveniences. This session lasted for an hour, and the structure mirrored that of the first focus group, with the same questions posed to understand and compare different perspectives. By maintaining consistency in the questions asked, the study aimed to draw comparative insights into gender perspectives on the same set of issues. It was later determined that gender did not significantly influence overall perceptions of safety and usability in the app's context.

The interview scripts for the micromobility experts were tailored to draw on the specific expertise of the individual, ensuring that the questions are directly relevant to their research areas and insights. Both scripts begin with a detailed introduction of the thesis goals, followed by a series of structured questions that probe the experts' knowledge and opinions on key issues related to e-scooter mobility. These questions are designed to elicit responses on how an e-scooter navigation app could address urban mobility challenges and safety concerns, ensuring that the prototype is grounded in expert knowledge and real-world applicability. A detailed version of both of the scripts for the expert interviews can be found in the attachments (**ANNEX B & ANNEX C**).

The expert interviews were conducted online using Google Meet, offering a flexible and accessible platform for both parties. Each session lasted about an hour, allowing for enough time to delve deeper into the topics of interest. The interviews were structured as in-depth interviews, divided into two main parts.

In the first segment of each interview, the focus was on the general role of e-scooters within the broader context of micromobility and urban environments. This part aimed to gather insights from the experts on their views of e-scooters as a component of urban mobility, identifying key issues, challenges, and opportunities from their specialized perspectives. Discussions covered topics such as the integration of e-scooters into existing transportation networks, safety concerns, regulatory impacts, and the environmental implications of e-scooter usage.

The second segment of the interviews concentrated more specifically on how a navigation application for e-scooters could enhance the experience of using these devices in urban settings. This portion sought expert opinions on potential app features, design considerations, and technological innovations that could improve safety, usability, and integration of e-scooters into daily commuting practices.

This dual-part structure allowed the interviews to cover both theoretical and practical aspects of e-scooter usage and app development, providing a rich, informed base from which to draw conclusions for the next phases of the research project.

Data collection during the focus groups was primarily done through audio recording to make sure every detail of the discussion was captured, and no crucial information was left out. Since the focus groups were conducted online, a recording software was used to ensure high-quality audio capture. Before each session, participants were informed about the recording process and its purpose. They were assured that the recordings were solely for research purposes and that all discussions would remain confidential. Consent was obtained from all participants, with clear communication that their personal information would be anonymized and protected (**ANNEX D**).

After each focus group session, the recorded audio was transcribed into text for a thorough analysis (**ANNEX E & ANNEX F**). This transcription process converted the dynamic interactions into a written format, making it easier to systematically examine the data. The following step involved performing a thematic analysis on the transcribed data. This analysis was crucial in identifying and categorizing key themes, insights, and ideas expressed by participants regarding their experiences and opinions on using e-scooter navigation apps. By breaking down the data into manageable themes, the analysis helped uncover patterns and draw meaningful conclusion from the discussions, enriching the overall research findings.

Similar to the focus groups, data collection for the expert interviews was done with audio recordings using a recording software. This method ensured that all the details discussed during the interviews were captured accurately, allowing for a comprehensive review and analysis later on. Prior to the interview, each expert was informed about the recording process, and consent was obtained, ensuring transparency and adherence to ethical research standards.

Once the interviews were completed, the audio recording were transcribed into text. This transcription aided in a detailed examination of the content, preserving the accuracy of the experts' responses and allowing for in-depth analysis (**ANNEX G & ANNEX H**). The transcribed data were then subjected to thematic analysis, a method chosen for its effectiveness in identifying, analyzing, and reporting patterns withing the data. The analysis was crucial for extracting meaningful insights from the complex discussions about e-scooters and the potential impact of navigation applications on urban mobility. Through this methodical approach, the research was able to refine the expert knowledge into actionable themes that directly informed the refinement and development of the e-scooter navigation app.

## **2.2. Prototype Development**

The prototype development was a crucial part of the research methodology, turning the insights from focus groups and expert interviews into practical, user-centered design solutions for an e-scooter navigation application. This phase aimed to translate theoretical data and professional opinions into a tangible product that could be tested and refined iteratively based on real user interactions and feedback.

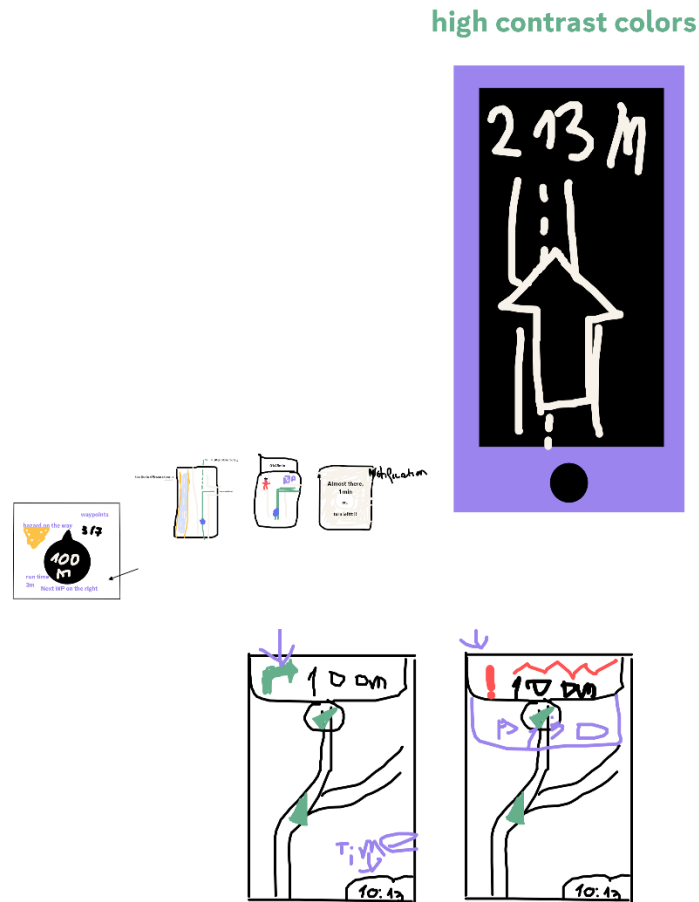
Prototyping in this research went beyond just creating an interactive prototype; it was about integrating the principles of multimedia design and usability tailored specifically to e-scooter users' needs. The process began with an initial design phase, where conceptual ideas and features suggested by users and experts were sketched out both visually and functionally. This was followed by the creation of a digital prototype using advanced design tools, and the implementation of participatory design, which directly involves users in the design process and allows for a deeper development of the app (Noorbergen et al., 2021).

### **2.2.1. Design process**

The design process for the prototype was deeply informed by the insights and contributions from the focus group participants and the micromobility experts, whose input was crucial in shaping the initial conceptualization of the e-scooter navigation application. During the first focus group session, participants actively engaged in the design thinking process, discussing necessary features and functionalities and visually interpreting their ideas through sketches (**Figure 5**). These sketches provided a valuable foundation, offering a visual representation of user expectations and preferences for the application's interface and functionality.

**Figure 5**

*Sketches of application designs by first focus group's participants*



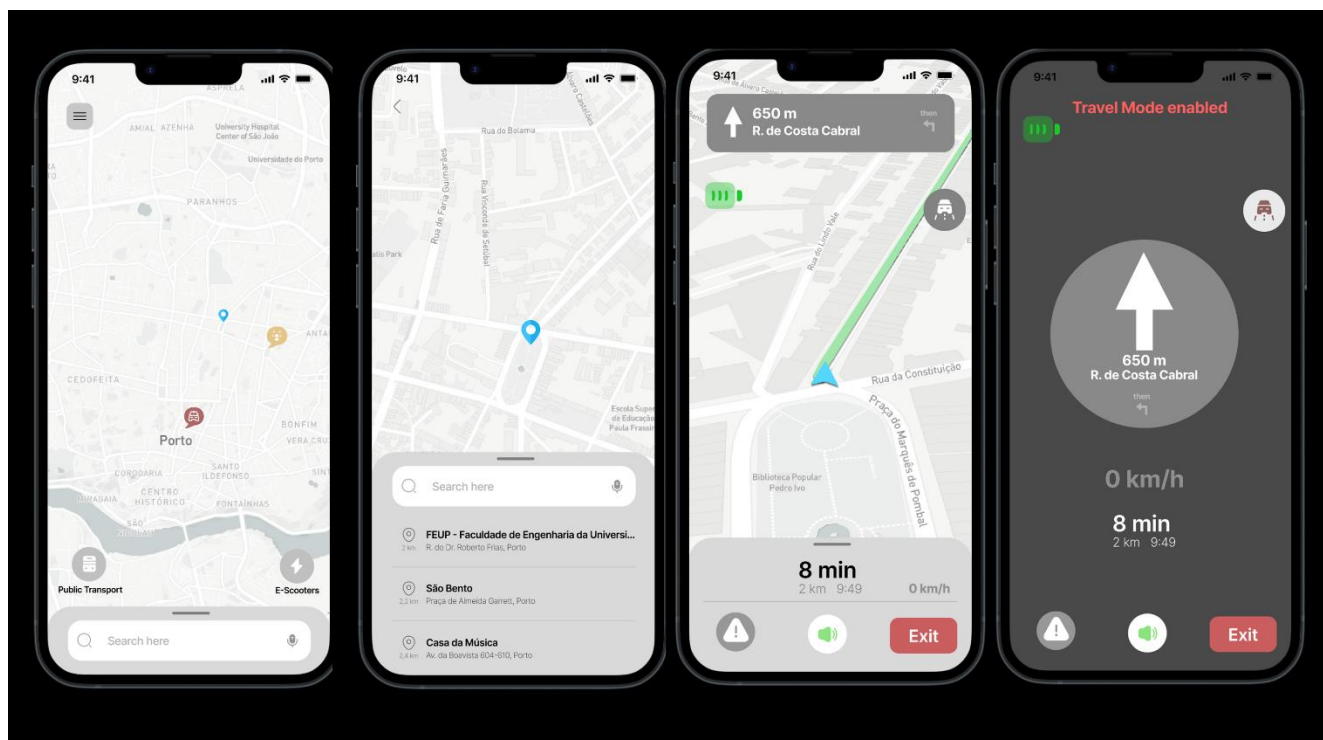
The second focus group, while not providing sketches, offered detailed verbal descriptions and feedback on design elements they deemed important for enhancing the user experience. Their insights were carefully documented and analyzed to ensure their preferences were acknowledged and incorporated into the design process.

Using Figma, a popular design tool known for its robust prototyping capabilities, and interactive prototype of the e-scooter navigation application was created (**Figure 6**). This prototype was designed to be highly interactive, allowing users to engage with the interface as they would with a fully functional app. Each button and interface element were linked to corresponding actions and responses, simulating the real-world use of the app. The interactive nature of the prototype not only allowed for evaluating the usability and intuitiveness of the design but also enabled dynamic testing and feedback sessions with users. By mirroring the actual application as close as possible,

the prototype provided a realistic experience for testers, ensuring that the feedback was relevant and actionable, further refining the application's design and functionality (ANNEX I).

**Figure 6**

*First version of prototype, done on Figma*



### 2.2.2. Testing and feedback

In the prototype design process, it is necessary to have a testing and feedback stage, which adopts a participatory design approach to ensure that the final product would meet user expectations and needs. Participatory design, a collaborative design technique, involves users directly in the development process, allowing them to contribute their perspectives and insights (Noorbergen et al., 2021). By engaging users directly, participatory design seeks to ensure that the outcomes more accurately reflect the users' needs and are more intuitive to use. This approach typically involves workshops, design sessions, and ongoing feedback mechanisms where users contribute ideas, express their preferences, and provide critical insights that shape the design direction. (Noorbergen et al., 2021). For this project, the method involves inviting users to participate in feedback sessions where they can interact with the prototype of the navigation app. During these sessions, users are given a demonstration of the app's functionality. In the focus groups, the participants voiced their needs for this type of application and gave valuable insight that was the fundamentals of the application. After the initial version of the prototype, the focus groups are

invited back for an extra session to see the prototype and express their opinions. The participants are encouraged to provide their insights on what aspects of the app work well and what could be improved. They are specifically asked to suggest any adjustments, additions or even deletions of certain features, in hopes to enhance the app's usability, effectiveness and aesthetic appeal. This feedback is invaluable as it comes directly from the end users who will ultimately be using the app in their daily lives. The collected feedback is meticulously analyzed to identify common themes and user preferences, which guide further refinements to the app. This iterative process of testing and gathering user feedback ensures that the final product is not only functional but also meets user expectations.

After the feedback session, the insights and comments on improvements and adjustments were written down and acknowledged. This evaluation produced a wealth of constructive feedback from the users. Initially, the plan was to iteratively adjust the prototype based on this feedback to enhance its user-centered design and functionality. However, due to time constraints, it was decided to instead acknowledge them as valuable suggestions for future enhancements. This approach ensures that the insights gained from the user feedback are preserved as recommendations, providing a clear direction for further improvement to make the app more user-centered and enjoyable to use. These suggestions will serve as a foundational guide for continuing the app's development beyond the scope of this thesis, aiming to fully realize a navigation tool for e-scooter users that is both highly effective and delightful to use.

### **3. Results**

This chapter presents a detailed exposition of the findings obtained from a series of methodologically diverse research activities aimed at developing an optimized navigation app for e-scooter users. Insights gathered from focus groups, expert interviews, and the iterative testing of the e-scooter app prototype are systematically outlined, with each section within this discussing the specific results, highlighting the critical themes and user preferences that have emerged.

#### **3.1. Focus Groups**

The focus group results provided valuable insights into the current usage patterns, preferences, and design needs for e-scooter users, highlighting several key areas for application development. Participants discussed a range of topics including the primary use of e-scooters for convenience and speed, the current challenges with navigation and safety, and the specific features they desired in a dedicated e-scooter app. Participants frequently mentioned the importance of safety

and navigation, expressing a preference for features that minimize distractions and enhance situational awareness while riding. This includes a strong interest in audio directions and alerts, which help keep users' eyes on the road, and real-time navigation updates that adapt quickly to urban dynamics.

Furthermore, there was an agreement on the need for a user interface that is minimalistic yet effective, allowing easy interaction without overwhelming the user. This ties closely with the desire for integration with existing urban infrastructure, such as real-time traffic data and public transport systems, to provide a seamless commuting experience.

The discussions also revealed frustrations with existing navigation apps such as Google Maps and Waze, particularly around the lack of specialized features for e-scooter navigation. The participants also talked about the lack of information of scooter availability and drop-off zones in the existing e-scooter sharing apps.

Key themes that emerged from these discussions included the need for a minimalistic yet functional interface that reduces distractions while riding. Users emphasized the importance of having clear and simple navigation cues, preferably augmented by audio directions to avoid having to look at the screen constantly. Safety features such as route optimization to avoid busy streets and real-time updates on road conditions were also highlighted as critical needs.

From these discussions, it was clear that there is a gap in the current market offerings regarding an e-scooter-specific navigation tool that addresses these user concerns effectively. The feedback provided will be instrumental in designing a prototype that not only meets the functional requirements of e-scooter users but also integrates innovative features to improve overall user experience and safety in urban environments. These insights directly inform and support the research questions aimed at identifying and integrating key usability and safety features into the prototype design, ensuring the final product aligns with user needs and preferences.

The focus groups, composed of diverse e-scooter users, revealed a spectrum of usage patterns that varied from daily commuting to occasional recreational use. During the focus groups, it was discovered that some users are more likely to take risks while driving e-scooters, while others seemed more careful. This was mostly highlighted when discussing one of the application's possible features to enhance user safety, which some users seemed as unnecessary, while others expressed it as a core feature of the app. The feature, travel mode in the app's map, minimizes distractions by limiting functionality while the e-scooter is in motion, was viewed by some as overly restrictive, and they expressed a need for flexibility, which they felt could enhance their user experience. But this request raises significant safety concerns, as disabling such features could lead to increased distraction, potentially resulting in unsafe e-scooter usage behaviors. This feedback points to the

necessity of balancing user-centered design with public safety concerns. The insights gained from these discussions are vital for informing future iterations of the app, ensuring that while user autonomy is respected, it does not compromise overall safety.

The feedback from these focus groups is crucial for the development of a prototype that not only addresses the functional requirements of e-scooter users but also incorporates innovative features to enhance safety and user experience in urban settings. The insights from this subchapter are instrumental in refining the research questions and guiding the design process, ensuring the final product effectively meets user needs and contributes to safer e-scooter navigation.

### **3.2. Expert Interviews**

The expert interviews conducted as part of the thesis research provided a deep dive into the practical applications and theoretical implications of e-scooter sharing platforms. The discussions with Expert #1 and Expert #2 helped explore several key areas, including the integration of e-scooters with public transportation, safety concerns, and the potential features of navigation apps designed specifically for e-scooter users.

Expert #1 highlighted the different usage patterns between tourists and residents, pointing out that while tourists often use e-scooters inappropriately due to unfamiliarity with local regulations, residents utilize them for practical purposes such as commuting. Both scenarios, however, emphasize the need for targeted safety measures and public awareness campaigns to mitigate risks and enhance the user experience. She also emphasized the potential for e-scooters to complement public transportation systems, especially in covering first and last-mile distances, suggesting that integration with public transport could significantly improve urban mobility efficiency.

Expert #2 provided a critical view on the integration of e-scooters into the urban fabric. He expressed concerns regarding the definitive impact of e-scooters on urban mobility, citing a lack of conclusive data and the need for enhanced regulatory frameworks to better harness the potential of micromobility solutions. They also discussed the vital role of navigation apps in improving safety, suggesting that features such as pre-trip planning and real-time traffic information could substantially reduce common safety issues associated with e-scooter use.

Both experts agreed on the necessity of thoughtful app design to address and mitigate the unique challenges posed by e-scooter traffic in urban areas. Experts emphasized the importance of safety enhancements, such as real-time traffic monitoring and route optimization, to prevent

accidents and improve the overall safety of e-scooter users in busy urban environments. Another significant theme was the need for regulatory alignment, where experts discussed how navigation apps could be designed to comply with local laws and regulations, thus facilitating smoother integration of e-scooters into existing traffic systems. Additionally, the necessity for data-driven decision-making was highlighted, with experts advocating for the use of extensive urban data to enhance the functionality of navigation apps, ensuring they are responsive to the dynamic urban landscapes.

Overall, the insights gathered from these interviews underline the importance of designing e-scooter sharing platforms and navigation apps that are not only user-friendly but also integrated with broader city infrastructure and public transportation networks to ensure a safe, efficient, and sustainable urban mobility landscape.

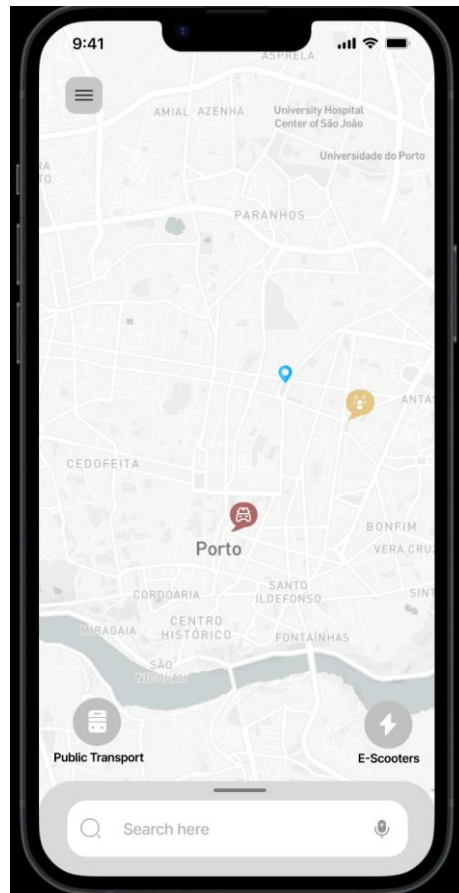
### **3.3. Prototype**

In the development of the e-scooter navigation app prototype, the initial set of features was directly informed by the insights gathered from the focus groups and expert interviews. These foundational features aimed to address the primary concerns and preferences identified by users and experts, such as enhanced safety protocols, intuitive user interfaces, and real-time traffic updates. This initial version was designed to test the feasibility and effectiveness of these features in a real-world application setting.

In the initial version of the e-scooter navigation app prototype, several key features were implemented to address the primary needs of urban e-scooter users, focusing on enhancing both safety and navigational efficiency. The features included in this first iteration were carefully selected based on the input received during the focus groups, aiming to create a comprehensive tool tailored specifically for e-scooter mobility in urban environments. One of the standout features of the prototype was its capability to provide real-time traffic updates and hazard alerts (**Figure 7**). This functionality was designed to inform riders of current traffic conditions and any potential dangers along their route, such as road closures, construction sites, or areas of high congestion. By integrating dynamic data feeds, the app helps riders make informed decisions on the go, potentially rerouting to avoid delays or unsafe areas, thereby enhancing the overall safety and efficiency of their travel.

**Figure 7**

*Hazard alerts in the prototype*

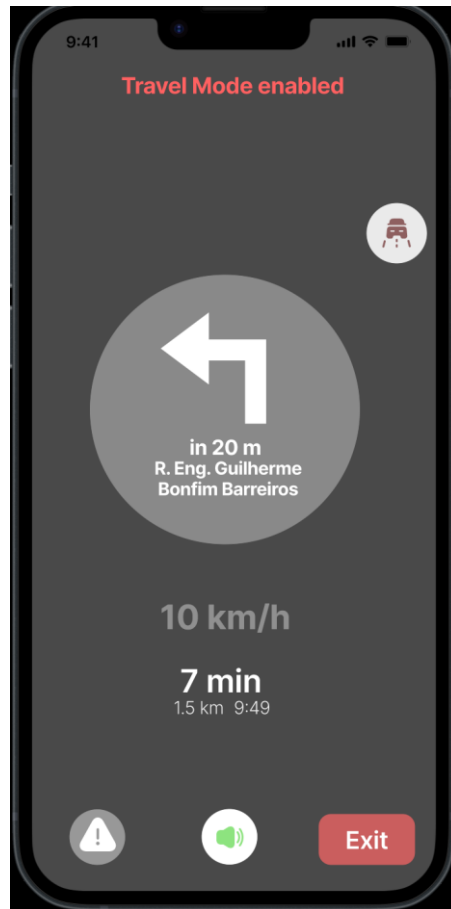


Recognizing the importance of e-scooters in the broader urban mobility ecosystem, the prototype also featured integration with local public transportation systems. This integration allows users to plan multi-modal journeys that combine e-scooter rides with public transit options, such as buses and metro. The app would provide seamless transition points and schedules, making it easier for users to plan the most efficient route across different modes of transport.

To ensure safety while the e-scooter is in motion, the prototype included a 'travel mode' for the map, which simplifies the display and enhances important navigational cues (**Figure 8**). This mode reduces the cognitive load on the rider by minimizing the amount of on-screen information and highlighting essential data, such as turn-by-turn directions and immediate next steps.

**Figure 8**

*Travel mode in the prototype*



Following the development of the first version of the prototype, it was presented to a selection of participants who had previously engaged in the focus groups. This approach allowed for a continuity of feedback, where participants could see how their initial input had been interpreted and integrated into the tangible app. During these sessions, participants interacted with the prototype, testing its functionality and usability. The feedback received was invaluable, highlighting both strengths and areas for improvement. Users provided specific insights on the app's navigation accuracy, ease of use, and the responsiveness of safety features under various urban mobility conditions.

One notable suggestion was the ability for users to save frequently visited locations within the app, which would allow for quicker and easier access, thus streamlining the navigation process. Users also recommended the inclusion of safety tips that would occasionally pop up on the main screen or during the loading screen of the app. These tips are intended to promote safe riding practices, enhancing user awareness and safety while using e-scooters. Participants also suggested the integration of a real-time weather feature at the top of the app's interface, which would not only

display current weather conditions but also alert users if the weather becomes unfavorable for e-scooter travel, such as during heavy rain or high winds. This feature aims to ensure user safety by advising against e-scooter use in potentially hazardous weather conditions. Lastly, the suggestion to include alternative routes when searching for directions was highly favored. This functionality would provide users with options to select the most convenient or safest route available, taking into account current traffic conditions and personal preferences.

This iterative feedback process was crucial for the subsequent refinement of the prototype. Each piece of feedback was carefully analyzed and used to further enhance the application, ensuring that the final product would not only meet but exceed the expectations and needs of potential users. This methodical testing and revision cycle underscored the project's commitment to developing a user-centered navigation tool, specifically tailored to enhance the urban e-scooter experience.

## 4. Discussion

This section synthesizes the insights derived from focus groups, expert interviews and prototype testing, exploring how they relate to established multimedia design principles and the specific requirements of mobile navigation applications for e-scooters. This discussion delves into how the collected empirical data align with and expand upon the theoretical frameworks covered in the literature, particularly focusing on user-centered design and the integration of smart technology with urban mobility systems.

The focus groups and expert interviews conducted provided valuable insights that closely align with the literature on multimedia design principles and the unique requirements of mobile navigation applications for e-scooters.

The focus groups revealed a strong user preference for navigation apps that prioritize safety and offer real-time information, echoing the themes discussed in the State of the Art regarding the need for user-centric design in multimedia applications. User-centric design was extensively discussed by Costello (2023), who discusses multimedia foundations and advocates for multimedia applications that enhance usability and interaction. The focus group participants, characterized by their diverse uses of e-scooters for commuting and recreation, provided a wealth of insights that resonate with the literature on user-centered design and mobility needs in urban settings. For example, the preference for real-time traffic updates and route customization options reflects a broader demand for smart mobility solutions that are adaptable to varying urban dynamics, a topic extensively discussed in contemporary research on urban transport technologies. Also, the state of the art extensively discusses how minimalistic design can reduce cognitive load as mentioned by Vic Costello, which is crucial when navigating complex urban environments on an e-scooter. Users' advocacy for minimalistic design choices during the focus groups directly aligns with these principles, emphasizing the need for clear, uncluttered interfaces that facilitate quick and easy comprehension of navigational cues. In the context of navigational cues, focus group participants were in favor for implementing not only visual, but also auditory and tactile cues into the application, allowing the users to receive necessary information about the directions or hazards, while keeping their focus on the road. The state of the art mentions the importance of this multiple times, mostly by Cybulski (2020), who says these elements help decision-making on the go, allowing the users to focus on driving without unnecessary distractions.

Similarly, the expert interviews emphasized the critical role of successfully integrating these applications with urban transportation infrastructures, a point that was heavily discussed in

the literature review. Hossain (2020) spoke about shared economy and the impact it does on urban mobility, and e-scooters are a prime example of that. The concept of shared economy encourages using micromobility, as well as integrating it with public transportation in hopes to alleviate city traffic and improving city environments. The experts' emphasis on safety and data integration provided practical viewpoints that reinforced the theoretical frameworks explored in the State of the Art, particularly in the context of smart cities and the integration of e-scooters into existing urban landscapes. The topic of safety was discussed by authors such as Nindl (2022), who mentioned that the reputation of e-scooters has been worsening. Wallgren (2023) and Cloud (2023) were also discussing the number of accidents that involved e-scooters and the main issues that caused them, which were the lack of helmet use, alcohol impairment and double riding, all which were mentioned and highlighted multiple times by the micromobility experts in the interviews. The experts' insights about the necessity for regulatory frameworks and data-driven navigation align with scholarly discussions on the importance of creating interconnected systems that not only enhance individual mobility but also contribute to broader traffic management strategies (Comi et al., 2024). Such integration helps to mitigate risks associated with e-scooter use, such as navigating through high-traffic areas or complying with varied municipal traffic regulations, issues that are extensively documented in the state of the art.

The insights from the users and experts directly influenced the design features of the prototype, ensuring that the app's interface was intuitive and minimally distracting, which once again supports the literature's emphasis on the importance of user interface design in enhancing user experience and safety.

The iterative feedback on the prototype highlighted the dynamic interaction between user experience design and practical usability, confirming the theories discussed about the effectiveness of multimedia design in improving navigational tools. This alignment not only validates the research questions posed at the outset of the study but also strengthens the arguments made about the potential of multimedia design to enhance the functionality and user experience of e-scooter navigation systems. This iterative process of testing and refinement highlights the practical implications of theories discussed in the state of the art. For instance, the application's focus on minimalistic design and user-friendly interfaces directly responds to the literature's call for reducing cognitive load to improve safety and efficiency in navigation apps, a topic extensively discussed by Vic Costello (2023). Additionally, the inclusion of features such as real-time traffic updates, hazard alerts, and alternative route suggestions within the prototype demonstrates the application of advanced data integration techniques discussed in academic circles, which are crucial for adapting

to the fluid dynamics of urban environments. The feedback from users during the focus groups and the feedback session provided invaluable insights that bridged the gap between theoretical research and practical application. It not only validated the relevance of the state of the art's recommendations but also showcased how these theoretical elements could be effectively translated into a functional tool that meets the end-users' needs.

Overall, the discussion ties the empirical findings back to the theoretical underpinnings discussed in the State of the Art, demonstrating how the research contributes to both academic knowledge and practical applications in the field of multimedia design and urban mobility. The discussions drawn from focus groups and expert insights have reinforced the essential role of minimalist design, real-time functionalities, and multi-modal sensory cues in enhancing the safety and efficiency of urban e-scooter mobility. Moreover, the insights from these empirical data sources have been pivotal in shaping the design and functionality of the prototype, ensuring that it not only adheres to but also advances the user experience through innovative integration of technology. The feedback implemented throughout the prototype testing phase have demonstrated a dynamic process of continuous improvement, rooted deeply in the principles discussed in the State of the Art. This iterative refinement process underscores the practical application of academic theories in real-world scenarios, bridging the gap between scholarly research and practical deployment. The findings highlight the necessity for ongoing research and development in this area, emphasizing the potential for further innovations that could continue to transform urban mobility landscapes. This synthesis of theory and practice provides a strong foundation for the final recommendations and future directions, setting the stage for continued exploration and enhancement of e-scooter navigation technologies.

## 5. Conclusion

In conclusion, addressing the first research question of this dissertation involved identifying the key usability and safety features that e-scooter users prioritize in mobile navigation apps. Through the analysis of focus group discussions and expert interviews, it became evident that e-scooter users significantly value features that enhance real-time interaction and situational awareness. Specifically, users highlighted the importance of clear audio instructions, which allow them to maintain their focus on the surroundings without constantly looking at a screen. Additionally, real-time traffic updates and route optimization that considers the unique speed and maneuverability of e-scooters were also deemed crucial for ensuring safety. The feedback emphasized a demand for an intuitive user interface with minimal distractions, helping riders navigate urban spaces safely and efficiently. These findings align with the broader goals of enhancing e-scooter mobility through improved app functionality, confirming the necessity for targeted design innovations that prioritize user safety and usability in the rapidly evolving landscape of urban transportation.

In addressing the second research question, this dissertation explored the perceived significance of dedicated e-scooter navigation apps on urban traffic flow and public safety. The insights gathered from expert interviews underscored a widespread recognition of the potential for e-scooter navigation apps to significantly improve urban mobility. Experts emphasized that well-designed e-scooter apps could alleviate urban congestion by providing more efficient routing options that divert e-scooter traffic away from busy roads and optimize the use of bike lanes and e-scooter-friendly pathways. Moreover, by reducing the likelihood of e-scooter riders navigating unsafely or illegally (such as riding on sidewalks or against traffic), these apps contribute positively to public safety. The potential to integrate these navigation systems with city-wide traffic management tools was also highlighted as a pivotal factor in enhancing overall urban traffic efficiency. This discussion revealed a strong belief among urban mobility experts that dedicated e-scooter apps, when effectively implemented, have a transformative potential to not only improve the safety of individual riders but also to enhance the overall flow and safety of traffic in densely populated urban environments.

In response to the third research question, this dissertation conclusively identified which prototype design features are most effective in enhancing the safety and navigational efficiency of e-scooter users in urban environments, based on prior research and expert feedback. The iterative development and testing process of the app prototype revealed that features such as predictive route planning, which anticipates potential hazards and recommends safer routes, are

crucial. Additionally, the incorporation of real-time data feeds that alert users to current road conditions and traffic updates was highly valued for promoting situational awareness. Experts and user feedback also supported the integration of geofencing technology to guide users away from restricted areas, thus enhancing compliance with local traffic laws. The consensus from both the user testing and expert consultations highlighted the importance of an interface that balances simplicity with functionality, ensuring that essential information is accessible without overwhelming the user. These features collectively contribute to a safer and more efficient navigation experience for e-scooter riders, directly addressing the core objectives of the research and paving the way for future enhancements in e-scooter navigation systems.

Based on the conclusions drawn from this research, several recommendations for future work in the development and enhancement of e-scooter navigation apps could be proposed. Firstly, enhancing the predictive analytics of the apps by integrating sophisticated algorithms that analyze historical traffic data and user behavior to offer accurate and proactive route suggestions could significantly enhance safety and efficiency. There is also a need for greater integration with city-wide traffic management systems, which would allow real-time communication between e-scooters and urban transport networks to optimize traffic flow and reduce congestion. Continuing to iterate on the app design based on ongoing user feedback is crucial, with future research involving larger scale testing across diverse demographics to ensure inclusivity, particularly for users with disabilities. Additional safety features, such as automatic speed regulators that adjust scooter speeds based on geolocation and traffic regulations, should be developed and tested to reduce accidents and improve law compliance. Moreover, partnering with urban authorities to roll out educational campaigns about safe e-scooter usage and the benefits of dedicated navigation apps could build a culture of safety and cooperation among all road users. Engaging with policymakers to develop and refine regulations supporting the safe integration of e-scooters into urban mobility, including setting standards for app functionalities that prioritize user safety and data privacy, is also recommended. Lastly, conducting environmental impact studies to assess the effects of widespread e-scooter use and the role of navigation apps in eco-friendly urban transportation strategies would support sustainable urban planning initiatives and promote the broader adoption of green mobility solutions. These comprehensive recommendations would continue to advance the utility, safety, and efficiency of e-scooter navigation apps, making them indispensable tools for modern urban mobility.

## 6. Bibliography

1. Al-Shaikh, R., Al-Malki, N., & Almasre, M. (2024). The implementation of the cognitive theory of multimedia learning in the design and evaluation of an AI educational video assistant utilizing large language models. *Heliyon*, 10(3), e25361. <https://doi.org/10.1016/j.heliyon.2024.e25361>
2. Bailey, B., & Sereda, S. (2020). The Sharing Economy: Do e-scooters make the cut? *MacEwan University Student eJournal*, 4(1). <https://doi.org/10.31542/muse.v4i1.1883>
3. Branis, M., Balint, G., Takacs, J., Sulik, M., & Galkin, A. (2020). *SHARED ELECTRIC SCOOTERS LIKE A TOOL OF A MICRO-MOBILITY IN CITIES*. 631–638. <https://doi.org/10.5593/sgem2020/6.1/s27.082>
4. Burney, A., Asif, M., Abbas, Z., & Burney, S. (2018). Google Maps Security Concerns. *Journal of Computer and Communications*, 06(01), 275–283. <https://doi.org/10.4236/jcc.2018.61027>
5. Cloud, C., Heß, S., & Kasinger, J. (2023). Shared e-scooter services and road safety: Evidence from six European countries. *European Economic Review*, 160, 104593. <https://doi.org/10.1016/j.euroecorev.2023.104593>
6. Comi, A., Hriekova, O., & Nigro, M. (2024). Exploring road safety in the era of micro-mobility: Evidence from Rome. *Transportation Research Procedia*, 78, 55–62. <https://doi.org/10.1016/j.trpro.2024.02.008>
7. Costello, V. (2023). *Multimedia Foundations*.
8. Cybulski, P., & Horbiński, T. (2020). User Experience in Using Graphical User Interfaces of Web Maps. *ISPRS International Journal of Geo-Information*, 9(7), 412. <https://doi.org/10.3390/ijgi9070412>

9. Dai, Y., Hasanefendic, S., & Bossink, B. (2024). A systematic literature review of the smart city transformation process: The role and interaction of stakeholders and technology. *Sustainable Cities and Society*, 101, 105112. <https://doi.org/10.1016/j.scs.2023.105112>
10. Dias, G., Ribeiro, P., & Arsenio, E. (2024). Perceptions of shared e-scooters service among university students in Braga, Portugal. *Transportation Engineering*, 16, 100231. <https://doi.org/10.1016/j.treng.2024.100231>
11. Fisú, A. A., Syabri, I., & Andani, I. G. A. (2024). How do young people move around in urban spaces?: Exploring trip patterns of generation-Z in urban areas by examining travel histories on Google Maps Timeline. *Travel Behaviour and Society*, 34, 100686. <https://doi.org/10.1016/j.tbs.2023.100686>
12. Hossain, M. (2020). Sharing economy: A comprehensive literature review. *International Journal of Hospitality Management*, 87, 102470. <https://doi.org/10.1016/j.ijhm.2020.102470>
13. Isik, G. K., Tryfonas, T., & Oikonomou, G. (2023). E-scooter Sharing Platforms: Understanding Their Architecture and Cybersecurity Threats. *2023 IEEE 26th International Conference on Intelligent Transportation Systems (ITSC)*, 5909–5916. <https://doi.org/10.1109/ITSC57777.2023.10421849>
14. Janikian, G. S., Caird, J. K., Hagel, B., & Reay, G. (2024). A scoping review of E-scooter safety: Delightful urban slalom or injury epidemic? *Transportation Research Part F: Traffic Psychology and Behaviour*, 101, 33–58. <https://doi.org/10.1016/j.trf.2023.12.015>
15. Jeon, M. (2017). Chapter 1—Emotions and Affect in Human Factors and Human–Computer Interaction: Taxonomy, Theories, Approaches, and Methods.
16. Kongsli Gjerde, H. (2022). HOW GRAPHIC DESIGN CAN INFLUENCE THE PERCEPTION OF SUSTAINABLE FOOD PACKAGING. *DS 117: Proceedings of the 24th International Conference on Engineering and Product Design Education (E&PDE*

- 2022), London South Bank University in London, UK. 8th - 9th September 2022. 24th International Conference on Engineering and Product Design Education.  
<https://doi.org/10.35199/EPDE.2022.102>
17. Krasner, J. (2008). Motion Graphics in Interactive Media.
  18. Kuo, L., Chang, T., & He, C.-B. (2022). Research on multimedia application development and color mode of App users. *Multimedia Tools and Applications*, 81(12), 17015–17032.  
<https://doi.org/10.1007/s11042-022-12488-w>
  19. Li, Y., Zhou, Y. (2023). Attention Allocation of Dynamic Icons on Mobile App Interfaces. (2023). *Tehnicki Vjesnik - Technical Gazette*, 30(3).
  20. Liu, M., Jones, C., & Hemstreet, S. (1998). Interactive Multimedia Design and Production Processes. *Journal of Research on Computing in Education*, 30(3), 254–280.  
<https://doi.org/10.1080/08886504.1998.10782226>
  21. Liu, Y., Hoseinzadeh, N., Gu, Y., Han, L. D., Brakewood, C., & Zhang, Z. (2024). Evaluating the Coverage and Spatiotemporal Accuracy of Crowdsourced Reports Over Time: A Case Study of Waze Event Reports in Tennessee. *Transportation Research Record: Journal of the Transportation Research Board*, 2678(4), 468–481.  
<https://doi.org/10.1177/03611981231185144>
  22. Makanadar, A. (2024). Neuro-adaptive architecture: Buildings and city design that respond to human emotions, cognitive states. *Research in Globalization*, 8, 100222.  
<https://doi.org/10.1016/j.resglo.2024.100222>
  23. Mitropoulos, L., Stavropoulou, E., Tzouras, P., Karolemeas, C., & Kepaptsoglou, K. (2023). E-scooter micromobility systems: Review of attributes and impacts. *Transportation Research Interdisciplinary Perspectives*, 21, 100888.  
<https://doi.org/10.1016/j.trip.2023.100888>

24. Nindl, F., Cerha, C. (2022). Is Sharing Caring? Consumer Responsibility for Rented Products: An Abstract. In: *Pantoja, F., Wu, S. (eds) From Micro to Macro: Dealing with Uncertainties in the Global Marketplace. AMSAC 2020. Developments in Marketing Science: Proceedings of the Academy of Marketing Science. Springer, Cham.*
25. Noorbergen, T. J., Adam, M. T. P., Teubner, T., & Collins, C. E. (2021). Using Co-design in Mobile Health System Development: A Qualitative Study With Experts in Co-design and Mobile Health System Development. *JMIR mHealth and uHealth*, 9(11), e27896.  
<https://doi.org/10.2196/27896>
26. Norman, D. (2007). *Emotional Design: Why We Love (or Hate) Everyday Things*. New York: Basic Books.
27. Occa, A., & Morgan, S. E. (2022). The role of cognitive absorption in the persuasiveness of multimedia messages. *Computers & Education*, 176, 104363.  
<https://doi.org/10.1016/j.compedu.2021.104363>
28. Ou, M., Zheng, H., Kim, H. K., & Chen, X. (2023). A meta-analysis of social media fatigue: Drivers and a major consequence. *Computers in Human Behavior*, 140, 107597.  
<https://doi.org/10.1016/j.chb.2022.107597>
29. Paduraru, E. (2022). *Fundamentals of Creating a Great UI/UX. Creative Tim.*
30. Ritchie, J., Lewis, J. (2003). *Qualitative research practice: A guide for social science students and researchers. Choice Reviews Online*, 41(03), 41-1319-41-1319.  
<https://doi.org/10.5860/CHOICE.41-1319>
31. Ruf, A., Zahn, C., Agotai, D., Iten, G., & Opwis, K. (2022). Aesthetic design of app interfaces and their impact on secondary students' interest and learning. *Computers and Education Open*, 3, 100075. <https://doi.org/10.1016/j.caeo.2022.100075>
32. Ruginski, I., Giudice, N., Creem-Regehr, S., & Ishikawa T. (2022). *Designing mobile spatial navigation systems from the user's perspective: an interdisciplinary review.*

33. Soares, M. M., Rosenzweig, E., & Marcus, A. (Eds.). (2021). *Design, User Experience, and Usability: UX Research and Design: 10th International Conference, DUXU 2021, Held as Part of the 23rd HCI International Conference, HCII 2021, Virtual Event, July 24–29, 2021, Proceedings, Part I* (Vol. 12779). Springer International Publishing.
34. Soegaard, M. (2018). *The Basics of User Experience Design*.
35. Tao, C., Guo, H., & Huang, Z. (2020). Identifying security issues for mobile applications based on user review summarization. *Information and Software Technology*, 122, 106290.  
<https://doi.org/10.1016/j.infsof.2020.106290>
36. Van Den Beemt, A., Akkerman, S., & Simons, R.-J. (2011). Considering young people's motives for interactive media use. *Educational Research Review*, 6(1), 55–66.  
<https://doi.org/10.1016/j.edurev.2010.06.002>
37. Wallgren, P., Rexfelt, O., & Nikitas, A. (2023). Comparing the bad media-fuelled reputation of e-scooters with real-life user and non-user perceptions: Evidence from Sweden. *Transportation Research Part F: Traffic Psychology and Behaviour*, 99, 189–203.  
<https://doi.org/10.1016/j.trf.2023.10.005>
38. Wickens, C. D., Gordon, S. E., & Liu, Y. (2002). *An introduction to human factors engineering: Christopher D. Wickens; Sallie E. Gordon; Yili Liu* (Nachdr.). Addison Wesley Longman.
39. Zallio, M. (2021). *Democratizing Information Visualization. A Study to Map the Value of Graphic Design*.
40. Zhang, Y., & Hong, K. (2022). Design and Production of Visual Image of Print Advertisement Based on Mobile Media. *Mobile Information Systems*, 2022, 1–10.  
<https://doi.org/10.1155/2022/4125623>

## **ANNEX A – Script for Focus Groups**

### **Script:**

Hello everyone! First of all, I want to say that I am very thankful to each of you for joining us today. Your input is incredibly valuable, and I'm thrilled to have you here as part of this exciting journey. My name is Mingailè and I'm a master in multimedia student from FEUP, working on my master thesis that aims to revolutionize the way we use and interact with e-scooters through a new mobile application.

Before we begin, let me give you some information what this is about. This project focuses on developing an app specifically designed for e-scooter users - think of it as your go-to for safer, smarter, and more enjoyable rides. Whether it's navigating city streets more efficiently or staying informed about safety features, we believe there's a lot of room for innovation in this space. And that's where you come in!

Today's discussion is all about hearing your voices - your experiences, ideas, preferences, and even the challenges you've faced while using e-scooters. Your perspective is crucial in shaping an app that meets real user needs.

Just letting everyone know that this session will be recorded strictly for research purposes. Your privacy and confidentiality are of most importance, and your personal information will not be disclosed.

During discussions, feel free to express your thoughts freely. There are no wrong answers here, just valuable insights.

So, before we begin with the questions, we'll start off with introductions. So, we can start off by telling everyone your name, age, a bit about yourself, and what draws you to use e-scooters.

[introduction]

### **Questions for focus group (users):**

#### **Introduction questions:**

1. Tell us about your experience with e-scooters.
2. Are e-scooters part of your daily life?

- a. How often do you use e-scooters for transportation?
- 3. What are your primary reasons for using e-scooters?
  - a. (Follow-up question) Could you explain why?
  - b. Usually, an e-scooter replaces what kind of transportation? (car, bus, walking...)
- 4. Which one is better in your opinion: owning an e-scooter or using a shared one?
  - a. (Follow-up question) Why?

#### **E-scooter and mobile applications questions:**

- 5. Can you describe what your typical e-scooter ride entails?
  - a. How do you usually navigate through the environment when using an e-scooter?
  - b. Do you use your phone *while* driving the e-scooter? Why or why not?
  - c. (if yes) Do you feel safe using an application while driving an e-scooter?
- 6. Do you use any mobile applications for navigation? Can you describe how you usually use them?
  - a. How would you describe your experience with these applications? Why?
- 7. If there was a mobile application for navigation tailored specifically to e-scooters, what features would you expect to see?
  - a. Why do you think this feature would be important?
  - b. (Can ask **optional** questions below)
- 8. Can you describe how you imagine the app to look like (colors, design)?
- 9. If the application were to be used while driving an e-scooter, what is your preferred way to receive information from it?
  - a. What kind of information should be shown?
  - b. In contrast, what do you think would only distract you and should be avoided?
- 10. To finish off, is there anything else you would like to share or add?

#### **(Optional, more specific questions)**

- 11. *If an app could provide real-time traffic updates and road conditions tailored for e-scooters, how useful would that be for you?*
- 12. *Would you use a feature that allows you to report hazards or issues to other e-scooter users in real-time?*
- 13. *Would voice navigation or hands-free operation features enhance your e-scooter experience? Why or why not?*

*14. What are your thoughts on integrating e-scooter apps with public transportation systems to provide a seamless urban mobility experience?*

Conclusion to focus group:

As we draw our discussion to a close, I want to take a moment to sincerely thank each of you for your invaluable contributions today. Your insights, experiences, and suggestions have not only enriched our conversation but have also provided essential guidance for the development and progress of the application and my dissertation. I would also like to reassure that all the information that was shared today will be treated with the utmost confidentiality and respect. The insights we've gathered will be used solely for the purpose of improving the e-scooter experience and research.

If you have any further questions, thoughts, or concerns after today's session, please don't hesitate to reach out.

Before we part ways, I want to ask when is a great time for everyone to get back together for another focus group, discussing the prototype that will be made from the suggestions I received today?

[decide on next meeting date]

Sounds great. Thank you once again and I hope to see you again next time. Have a wonderful day!

## **ANNEX B – Script for the Expert Interview with Expert #1**

### **Interview Script**

Hello,, and thank you so much for agreeing to speak with me today. My name is Mingailè, and I'm a Master's student at University of Porto, Faculty of engineering, and I'm working on my thesis titled 'Mobile Applications for E-scooter Navigation: A Multimedia Design Approach.' In short, my thesis focuses on developing a navigation application specifically designed for e-scooter users, so my research aims to explore how these e-scooter navigation apps can be designed and integrated into urban transportation systems to enhance safety, efficiency, and accessibility for all users. Your extensive research on urban mobility and micromobility, has been incredibly insightful for understanding the complexities of this mode of transportation within urban environments.

Today, I'd like to discuss how your knowledge can inform the development of e-scooter navigation apps, especially in enhancing safety and efficiency within urban transportation systems. Also, I'd like to inform you that this interview will be recorded strictly for research purposes. Your privacy and confidentiality are of most importance, and your personal information will not be disclosed. Is that okay?

1. So, before we begin, could you briefly introduce yourself? Like age, academic background and the theme of your PhD thesis?

#### **[Ground mapping questions]**

2. How do you perceive the role of e-scooters in enhancing urban mobility?
3. In your research, have you identified any significant impacts of e-scooters on traffic?
  - a. How do these impacts vary across different city environments?
4. In your paper, you highlighted the increasing urbanization and its impact on vehicle numbers. How do you see the role of micro-mobility evolving in this context, especially in densely populated urban areas?
5. Based on your studies, can e-scooters be effectively integrated with public transportation systems to enhance urban mobility?
  - a. What are the key factors that facilitate or hinder this integration?

6. Were you able to identify instances where e-scooters have replaced cars for certain types of trips?
  - a. What are the primary conditions or incentives that encourage users to choose e-scooters over cars?

[Dimension mapping question]

7. In your opinion, should navigation apps be used while riding e-scooters, or are there significant safety concerns that outweigh the benefits?
8. Considering the safety challenges with micro-mobility you identified in your study, such as inexperienced users and unclear regulations, what features should e-scooter navigation apps incorporate to improve safety and comply with regulatory changes?
9. How does the increasing use of e-scooters impact urban traffic flow?
  - a. (if any negative impact is mentioned) and can a navigation app for e-scooters help reduce any negative effects?
10. You found that 'side collisions' and 'collisions with obstacles' are common accidents involving micro-mobility devices. How can e-scooter navigation apps be designed to help users avoid these risks?
11. Your paper highlights the importance of integrating micro-mobility with public transportation. What functionalities should e-scooter navigation apps include to facilitate seamless integration with other modes of urban transport?
12. Do you think e-scooter navigation apps can play a significant role in supporting the long-term sustainability of e-scooters in urban transportation networks?

[Perspective widening questions]

13. As someone deeply involved in the study of urban mobility, what are your personal hopes or concerns for the future of micromobility and e-scooters?

Okay, I think we're done with the questions. Before we close this up, do you have any additional comments or questions?

I want to express my sincere gratitude for taking the time to speak with me today. Your insights have been incredibly valuable and will significantly enrich my thesis. The depth of your expertise in micromobility has provided me with a broader perspective on the challenges and opportunities for e-scooter navigation apps. I truly appreciate your willingness to share your knowledge and help guide my research.

## **ANNEX C – Script for the Expert Interview with Expert #2**

### Interview script

Hello, and thank you so much for agreeing to speak with me today. My name is Mingailè, and I'm a Master's student at FEUP, working on my thesis titled 'Mobile Applications for E-scooter Navigation: A Multimedia Design Approach.' In short, my thesis focuses on developing an app specifically designed for e-scooter users, so my research aims to explore how e-scooter navigation apps can be designed and integrated into urban transportation systems to enhance safety, efficiency, and accessibility for all users. Your extensive research on urban mobility and micromobility, particularly regarding e-scooters, has been incredibly insightful for understanding the complexities of this mode of transportation within urban environments.

Today, I'd like to discuss how your knowledge can inform the development of e-scooter navigation apps, especially in enhancing safety and efficiency within urban transportation systems. Also, I'd like to inform you that this interview will be recorded strictly for research purposes. Your privacy and confidentiality are of most importance, and your personal information will not be disclosed. Is that okay?

1. So, before we begin, could you briefly introduce yourself? Like age, academic background and the theme of your PhD thesis?

### [Ground mapping questions]

1. How do you perceive the role of e-scooters in enhancing urban mobility?
2. In your research, have you identified any significant impacts of e-scooters on traffic?
  - a. How do these impacts vary across different city environments?
3. Based on your studies, can e-scooters be effectively integrated with public transportation systems to enhance urban mobility?
  - a. What are the key factors that facilitate or hinder this integration?
4. Were you able to identify instances where e-scooters have replaced cars for certain types of trips?

- a. What are the primary conditions or incentives that encourage users to choose e-scooters over cars?

[Dimension mapping question]

5. In your opinion, should navigation apps be used while riding e-scooters, or are there significant safety concerns that outweigh the benefits?
6. Your research also highlighted significant safety concerns among e-scooter users, particularly regarding head injuries and illegal parking. How could navigation apps contribute to mitigating these risks and enhancing overall safety in urban environments?
7. How does the increasing use of e-scooters impact urban traffic flow?
  - a. (if any negative impact is mentioned) and can a navigation app for e-scooters help reduce any negative effects?
8. In your studies, you've observed usage patterns around city centers. What strategies can navigation apps implement to reduce e-scooter congestion in high-traffic areas?
9. Your research in Braga showed e-scooters as a potential asset for sustainable policy goals. How can navigation apps facilitate intermodal connectivity, making e-scooters a more integrated part of the wider urban transport network?
10. Given the role of e-scooters in intermodal travel, what features in navigation apps are critical for facilitating seamless transitions between e-scooters and other modes of transport?
11. Considering your research on the promotion of equity and sustainability, what role do you see for e-scooter navigation apps in supporting the long-term sustainability of e-scooters in urban transportation networks?

[Perspective widening questions]

12. As someone deeply involved in the study of urban mobility, what are your personal hopes or concerns for the future of micromobility and e-scooters?

Okay, I think we're done with the questions. Before we close this up, do you have any additional comments or questions?

I want to express my sincere gratitude for taking the time to speak with me today. Your insights have been incredibly valuable and will significantly enrich my thesis. The depth of your expertise in urban mobility and micromobility has provided me with a broader perspective on the challenges and opportunities for e-scooter navigation apps. I truly appreciate your willingness to share your knowledge and help guide my research.

## **ANNEX D – Consent Form for Focus Group participants**

### **Focus Group Consent Form**

#### **Purpose**

You have been invited to participate in a focus group organized by Mingailė Aušrinė Maželytė under the supervision of Luciano Moreira of the Faculty of Arts and Humanities of University of Porto, Sara Ferreira and Bruno Cardoso of the Faculty of Engineering of the University of Porto in the context of her dissertation in the Master in Multimedia titled “A Multimedia Design Approach for On-The-Go E-scooter applications”. The purpose of this focus group is to figure out and analyze how to apply multimedia design to create an application that would provide users with essential information with as minimal design as possible. The information learned in this focus group will be used to prototype a mobile application for e-scooters that can be effectively and safely used while using an e-scooter on the road.

#### **Procedure**

As part of this study, you will be placed in a group of 6 – 10 individuals. A moderator will ask you several questions while facilitating the discussion. The focus group will be audio-recorded, however, your responses will remain confidential, and no names will be included in the final report.

You can choose whether or not to participate in the focus group, and you may stop at any time during the course of the study.

Please note that there are no right or wrong answers to focus group questions. We want to hear the many varying viewpoints and would like for everyone to contribute their thoughts. Out of respect, please refrain from interrupting others. However, feel free to be honest even when your responses counter those of other group members.

#### **Confidentiality**

Should you choose to participate, you will be asked to respect the privacy of other focus group members by not disclosing any content discussed during the study. The data will be analyzed, your responses will remain confidential, and no names will be included in any reports. Data will

be stored in the main researcher's computer device for 2 years, and only accessible to the researchers. After the period of 2 years, data may be anonymized and shared with the scientific in a open repository.

## Contact

If you have any questions or concerns regarding this study, please contact:

Mingailė Aušrinė Maželytė

up202204425@edu.fe.up.pt

+37065071166

*I understand this information and agree to participate fully under the conditions stated above.*

Sign name: \_\_\_\_\_ Date: \_\_\_\_\_

Print name: \_\_\_\_\_

# **ANNEX E – Focus group transcript #1**

## **Focus Group Transcript**

Date: 2024-04-08

Duration: 30-40 minutes

Host: Mingailė (M)

Participants:

- Kostas, 23, Lithuania (**KO**)
- Ažuolas, 21, The Netherlands (**A**)
- Daniel, 23, Spain/Portugal (**D**)
- Kernius, 22, Lithuania (**KE**)

**M:** Hello everyone! First of all, I want to say that I am very thankful to each of you for joining us today. Your input is incredibly valuable, and I'm thrilled to have you here as part of this exciting journey. My name is Mingailė and I'm a master in multimedia student from FEUP, working on my master thesis that aims to revolutionize the way we use and interact with e-scooters through a new mobile application.

Before we begin, let me give you some information what this is about. This project's main goal is to develop an app, a minimalistic app, specifically designed for e-scooter users - think of it as your go-to for safer, smarter, and more enjoyable rides. The goal is to create an app that could be used while driving the e-scooter, without distracting the user too much, but providing valuable information. Imagine Waze or Google maps, but just for e-scooters. So basically, whether it's navigating city streets more efficiently or staying informed about safety hazards, I believe there's a lot of room for innovation in this space. And that's where you come in!

Today's discussion is all about hearing your voices - your experiences, ideas, preferences, and even the challenges you've faced while using e-scooters. Your perspective is crucial in shaping an app that meets real user needs.

Just letting everyone know that this session will be recorded strictly for research purposes. Your privacy and confidentiality are of most importance, and your personal information will not be disclosed.

During discussions, feel free to say what's on your mind. There are no wrong answers here, just valuable insights.

So, before we begin with the questions, why don't we start this off by introducing ourselves? Let's start by telling everyone your name, your age, maybe a bit about yourself, and how long have you been using e-scooters.

**A:** Who's going first?

**KO:** I can start. Okay, my name is Kostas. I am 23 years old and there was a period of two and a half months when I actively used an e-scooter. And that's why I wanted to participate in this focus group so I could share my experience.

**M:** Okay, thank you so much! Who's next?

**KE:** I can go. My name is Kernius, I'm 22, I am a first year IT student and I've been using e-scooters on and off for about 3 years.

**M:** Okay, thank you.

**A:** My name is Ažuolas, I'm 21, and I basically use e-scooters on a daily basis.

**M:** Love that.

**D:** I think it's only me left. I'm Daniel, I'm 23 years old, and I became a fan of e-scooters when I moved out to live alone, and now I use e-scooters every 2 to 3 days.

**M:** Okay, thank you everyone, it's very nice to meet you. So, since you already told me about your experience with e-scooters, I'll go ahead and ask what are your primary reasons for using an e-scooter?

**A:** To me, I have to get to university, and by foot it is 30 minutes, which isn't the worst, but it's just not nice, you know, those extra 30 minutes can get a long way in the morning, so I use it to get there faster. Also, I live about 30 minutes from the city center, and I use it to get there too. The public transport in the Netherlands is a little bit expensive.

**M:** Okay.

**KO:** For me, I mostly use it to get to work and back, and that would usually save me around 20 to 30 minutes, because public transportation would take like 50 minutes to an hour, but using an e-scooter would usually take a consistent 20 to 25 minutes.

**M:** So this is more like to avoid traffic jams?

**KO:** Basically, just to get a consistent time to the destination.

**M:** Okay, got it.

**KE:** For me personally, I use e-scooters to mainly drive around the city center, because I don't want to take my car there. It's usually very crowded and hard to navigate, and I mostly use e-scooters for short trips, simply to get from point A to point B whenever I need to.

**D:** For me, I use it to go to university or to other places, for example to play tennis, because it takes me it takes me like 3 minutes in the case of tennis and around 10 minutes to university. I also like to go out late with my friends so I cannot rely on public transport and I like to just take the e-scooter, which is in front of my house, to meet up with my friends.

**M:** Okay, thank you. And do you own your own e-scooter or do you prefer using the shared ones, like Bolt? Which one do you think is better?

**A:** I have my own, but I think it depends very much on the service. From my experience, in Spain, they were very affordable, but in other countries, if you're planning on using it on a daily basis it can be quite expensive, so I think it's better to just buy your own e-scooter.

**KO:** Yeah, I think for usage for set destinations, like university or work, where you go to everyday, the private one would be the better option, but if you're going to use just to get around the city center, I think the shared ones will be more advantageous, because you don't have to worry where to leave it, cause you can basically leave it anywhere.

**KE:** I personally don't have my own e-scooter and I only use the shared ones.

**M:** Is there a reason why?

**KE:** As I mentioned, I only use them in the city center or just to get to point A to point B when I'm out, and I don't really use it to get from my home to somewhere else, so I don't own my own, I just rent them whenever I see fit.

**D:** Yeah, I also don't have my own e-scooter, and I actually only do very short rides, I never know where I'm going to be so I prefer not to worry about where to park it.

**M:** Okay, that makes sense. So, could you try to describe to me how your usual trip with an e-scooter goes? For example, how do you navigate through the environment, do you use your phone at all?

**A:** For me, Since I have my own e-scooter, I usually just take it out of my apartment and since I usually go on trips where I know where I need to go, I just follow the bike paths and that usually does it for me. But when I need to go to places where I don't necessarily know where I'm going I usually just use a phone holder. And on the phone holder is of course google maps, maybe spotify.

**M:** Okay, and do you think it's safe to use the applications when driving the e-scooter? Do you find it easy to multitask like that?

**A:** Probably not, I would say like out of most private vehicles I feel like it's the worst one to drive and use the phone, because the front swivels a lot more, compared to, for example, a bike. I usually don't really like doing it as I ride, usually I set it up before I need to move, unless I really need to do like a quick button thing, then I can do it while driving, but I prefer not doing that.

**KO:** Also adding to this point, even if the phone is on the holder, the phone is still really below you, from your vision, so you really need to look down to see something on your phone, so it can really distract your vision.

**A:** True.

**KO:** So, actually it could be better if applications used some sound indications.

**KE:** For me, personally, there are two scenarios how I navigate around places. The first one is when I know where I want to go and I know the road I want to take, then I just navigate by myself, and the second one is the more frustrating one, especially since a lot of the shared e-scooters don't have phone holders. So I just try to memorize where I want to go for a few hundred meters, I go those few hundred meters, then I stop, check my phone again, I check, and repeat until I get to the place I want to get. But that takes up a lot of time and in extra scenarios I may take out my phone while on the scooter and going slowly, but that is quite risky and I would much rather depend on some sound signal or if I had a phone holder, [the app could have] just a very large scale model of the directions that I could just glance at it and know where I should navigate and not be distracted from the road too much.

**D:** I think my case is also the same as the last person. I have two scenarios: either I know where I'm going, which is fine, or if not, I need to keep stopping every few hundred meters to see what's the next direction. It is also frustrating when I need to find a new drop-off zone for the e-scooter, because you can't leave it anywhere you want, you need to find a spot for it, and I cannot set the route for the drop-off spot inside the application, like in google maps.

**M:** Okay, so you think if it would be possible to see the nearest drop-off zones near your destination it would be useful?

**D:** Yes.

**M:** I guess that kind of leads me to my next question, which is if there was a mobile application for navigation tailored specifically to e-scooters, what features would you expect to see?

**A:** Probably I would expect a simple UI, just something that doesn't clog up my travel process, just something very streamlined and simple and so it's good to use on-the-go. I think it should definitely, if we're talking about having a whole map functionality in it, I think it should have markers for drop-off spots, and it should say how many scooters are there. Because I think if you're using them on a daily basis and you're in a crunch of time, you could just look at the app and see "okay, there is a scooter in this one" and I don't need waste time if the drop-off spot I go to doesn't have a scooter and that would mean I would need to go to a new one and figure out if there are scooters there. I think that saves time. So that's more about the using side, prior to actually riding. And while riding, I think sound indications are very important, as it was said already, it is difficult to constantly look down, it really obstructs your view, so audio and clear, simple, directions. Maybe like instead of having the whole map laid out, you could just use arrows to show like, for example, in the next hundred meters, what direction you have to follow. Like a compass thing, maybe.

**KO:** That is what I actually wanted to add to Ažuolas's point, very well noticed.

**M:** The arrows, you mean?

**KO:** Yeah.

**A:** Something like a compass, I think, would be super simple to use and understand while on a ride.

**KO:** Basically, a waypoint, directions, and meters.

**A:** Yeah.

**KO:** Also, it could be used in two stages: like before accepting the route, you can look at the map where you have to go, and then when you press start it switches to the simplified version.

**KE:** Yeah, a lot of good points mentioned. As previously mentioned, I think the most important thing would be a very clearly visible map to see where you're going so it would be efficient enough to just glance at it and know the general direction and where you need to go next and in how many meters the next maneuver should be. I also agree with all the previous points.

**D:** Yeah, I also agree with all points, definitely the most important for me would be having a mini map, very simple, which shows me with an arrow and a line, highlighted in a different color, where do I have to turn left or right, and also the drop-off zones, in case there's one nearby and I didn't see it or mark it in the beginning. And also, there could be a voice instruction like google maps, like for example "in 30 meters, turn left" or something.

**KO:** Also, it would be a good thing to implement the system that Waze uses, that you could put a "danger zone" on the map.

**M:** Oh, like report hazards on the road?

**KO:** Yes, yes. Because, well, maybe for scooters traffic isn't really relevant, but, let's say, something like construction or potholes would be kind of necessary to know.

**D:** Also, if there is a bike lane nearby, instead of going on the pavement or the road, you could highlight the bike lane and choose that type of surface.

**M:** Oh, like the app would tell you that there's a bike lane nearby?

**D:** Yeah, like it would be marked in red or something to show that there is a safer option for the users.

**M:** Okay. Regarding the features, do you think it would be useful to add maybe a feature that would like integrate the app with public transportation systems? Do you think it's a necessity to combine e-scooters with public transport?

**KO:** I think for some cases it could be quite a good option, if there's no nearby bus station or metro station near your destination, so you could take the nearest possible bus or metro route and then finish it with an e-scooter.

**M:** So you think it would be an useful addition to the app? Like it could calculate, let's say, a bus route and then give you a location to the nearest e-scooter station, or do you think that's too niche?

**KO:** No, I think it would be a great addition.

**A:** I think that, although it's a great idea, and some apps do this, like in The Netherlands, the government department that owns the trains also own a bike system, and if you look up on the app how to get somewhere, it shows the options by train, tram, bus, metro and by bike, so I think it could be a cool integration. But I also think that's something for public transportation apps to do, not for your e-scooter application.

**KE:** Yeah, I would also agree with that opinion. I believe that public transport options should be showed only in very extra or edge cases, because I would want a e-scooter app only to be about scooters and I would want to see information only related to e-scooters. Maybe a suggestion to use an another application for public transport would suffice, because I wouldn't want an app that does everything, I want the app to focus on one thing and do it well.

**A:** I agree with that.

**D:** Yeah, same. Honestly, I wouldn't trust an e-scooter application for taking the metro.

**M:** That makes sense. Okay, I think we already discussed this briefly, but I'll ask it again just in case. If for example, you would use the application while driving the e-scooter, what is your preferred way to receive the necessary information?

**A:** Sound. I'm always wearing headphones, so sound is going to be the easiest for me.

**KO:** And as a secondary way, a quick and simple visual indication of your next direction.

**KE:** I would also agree. Because when I ride, I also wear headphones most of the time, although whenever I don't, I think it would be also efficient to create a pop-up notification, that rings no matter if you have sound turned on or not, and it would show the information you need to see in big letters or just a very noticeable way. Also, the phone could vibrate, although it probably wouldn't transfer very well and you wouldn't feel it if the phone was on the phone holder, but it could also be an option.

**D:** Sound, a very big pop-up notification, and I think a vibration would also be good.

**M:** So, if I understood correctly, sound should be the main source and then visual indicators as an addition?

**All:** Yes.

**M:** Okay. And what kind of information do you think is the most necessary? Should it only be the navigation, or would you want to know something more? Like, as you mentioned, hazards, or do you think that would be too much of a distraction?

**A:** I think direction is the most important. Second is the time that you've been using the scooter, because some scooters charge you by the minutes you've used it, so it would be nice to know how long I've been using it. And then the third concern would be the hazards.

**KE:** Yeah, I also agree that the most important thing would probably be direction, hazards and some time frames or maybe if I set a limit on how long I want to use the scooter I would get a notification if I used it longer than I wanted to. Also, for a rented scooter, if I were to exit the parking zone or I would cross any zones, I think it would also be important to know as well.

**KO:** Adding to the first point regarding directions, I think the distance until the next turn.

**A:** Yeah, true.

**D:** I really like the one about how much time I've been using the e-scooter, because in my case they usually charge by time. Actually, it happened to me a few times that I've ran out of battery while riding an e-scooter and I wasn't near a drop-off zone, and I don't really know what to do in that case. So, maybe if it could alert in advance that your e-scooter is running out of battery, and show you the nearest drop-off zone.

**KO:** But I think that would be a very e-scooter specific app, like the company that provides you the scooter.

**D:** Yeah. I don't know if you can check the battery in the application, but in case, it would be nice. If not, that's fine.

**KO:** Because, in my opinion, this app should be universal for all scooters, no?

**M:** Yeah, that is the goal. It's basically like google maps, which is used universally, but just specifically for e-scooters. But not for a specific brand of e-scooters, just like in general. But, do you think it could be useful to connect with brand specific apps, like, for example, Bolt?

**KO:** I guess it could be possible to collaborate with brands. But probably would be very expensive for a start-up application.

**D:** But it would also be kind of weird opening up Bolt, and then redirecting to an another app, could be a bit confusing.

**M:** Okay, thank you. I think I'm done with the questions, so the last one would be is there anything else you'd like to add, share, or ask?

**KO:** I think there should be an option to choose if you're using your own scooter or if you're using a shared scooter.

**KE:** Yeah, I agree. That would be nice.

**M:** Is there a reason why?

**KO:** Because you don't need to know the drop-off zones if you ride a personal e-scooter.

**KE:** Yeah, and if you considered integrating other e-scooter apps in your application it wouldn't really be relevant for users who have their own e-scooters.

**M:** Okay, that makes sense. Alright, so if nobody else has nothing to add, I want to take a moment to sincerely thank each of you for your contributions today. Your experiences and suggestions have provided essential guidance for the development and progress of the application and my dissertation. If you have any further questions, thoughts, or concerns after today's session, please don't hesitate to reach out. Before we part ways, I want to ask if it would be possible to meet up again after a few weeks, discussing the prototype that will be made from the suggestions I received today?

All: Yeah, sounds good.

M: Okay, we'll discuss the date of the next meeting in a few days. For now, thank you once again and I hope we talk again soon. Have a nice evening!

## **ANNEX F – Focus group transcript #2**

### **Focus Group Transcript**

Date: 2024-05-01

Duration: 1 hour

Host: Mingailė (**M**)

Participants:

- Lile, 24, Georgia/Lithuania/Portugal (**L**)
- Vika, 23, Ukraine/Lithuania/Portugal (**V**)
- Revishvili, 23, Georgia/Lithuania (**R**)
- Cholponai, 23, Kyrgyzstan/Lithuania (**C**)

**M:** Hello everyone! First of all, I want to say that I am very thankful to each of you for joining us today. Your input is incredibly valuable, and I'm thrilled to have you here as part of this exciting journey. My name is Mingailė and I'm a master in multimedia student from FEUP, working on my master thesis that aims to revolutionize the way we use and interact with e-scooters through a new mobile application.

Before we begin, let me give you some information what this is about. This project's main goal is to develop an app, a minimalistic app, specifically designed for e-scooter users - think of it as your go-to for safer, smarter, and more enjoyable rides. The goal is to create an app that could be used while driving the e-scooter, without distracting the user too much, but providing valuable information. Imagine Waze or Google maps, but just for e-scooters. So basically, whether it's navigating city streets more efficiently or staying informed about safety hazards, I believe there's a lot of room for innovation in this space. And that's where you come in!

Today's discussion is all about hearing your voices - your experiences, ideas, preferences, and even the challenges you've faced while using e-scooters. Your perspective is crucial in shaping an app that meets real user needs.

Just letting everyone know that this session will be recorded strictly for research purposes. Your privacy and confidentiality are of most importance, and your personal information will not be disclosed.

During discussions, feel free to say what's on your mind. There are no wrong answers here, just valuable insights.

So, before we begin with the questions, why don't we start this off by introducing ourselves? Let's start by telling everyone your name, your age, maybe a bit about yourself, and what drives you to use e-scooters or how long you've been using e-scooters.

R: Hello, my name is Revishvili, I am 23 years old and I'm from Georgia but I currently live in Lithuania. I've been using e-scooters since 2019. I remember it was pre-pandemic but not specifically sure what month it was when I used them for the first time, but it was 2019.

C: Hello, my name is Cholponai, but you can call me Cholpa. I'm 23 years old I'm from Kyrgyzstan and currently I'm in Lithuania. What drives me to use e-scooters is probably when I'm sad, lonely or just bored. I feel like it makes me feel more free and happier or something like that, like it brings me adrenaline, because I'm the type of person who's afraid of some things. Like, I cannot drive a car, so driving e-scooters gives me some kind of freedom.

M: Oh, that's lovely.

L: Okay, hi, my name is Lile, I'm 24 and I am from Georgia originally but right now I live in Porto, Portugal. I love using e-scooters because they're really fast, they're efficient, they're practically all over the city, depending on the city, obviously. And in some places they're cheaper than like ordering an actual taxi, for example. And as Cholpa described it is a very liberating experience to just go through streets on an e-scooter, I just love it.

V: Okay, so, my name is Vika, I'm 23 and I am from Ukraine, I also spent a long time in Lithuania but now I'm in Porto. I started using scooters in Lithuania because it is a very flat country and Klaipėda, the city I lived in, had good roads and you were able to just go straight without making many turns and reach your destination, and as Lile mentioned, it was way cheaper than ordering a taxi. And yeah, I would also agree that it is very liberating.

M: Okay, thank you and it is very nice to meet you all! Now, moving on with the questions, would you say that e-scooters are part of your daily life? How often do you use them?

V: For me, I don't use them that often anymore. Back in Lithuania, I would use them probably once a week, but since I came to Porto and since there are so many hills here, and no roads for e-scooters, I used it only a few times.

L: It's the same for me. I used it very often in Lithuania, especially in summer, I was using it practically every other day. Plus, it was much cheaper to use it in Lithuania, here in Porto it's very expensive, so I use them rarely.

R: E-scooters are expensive?

L: Yeah.

M: I didn't know that it was more expensive here, I thought they were similar prices.

V: Apparently, when you go up a hill it takes more time so in the end you have to pay more money.

M: Oh, that makes sense.

C: For me, I think it depends on when the next bus arrives, so I think I use e-scooters like once a week, probably. If I have to wait for the bus for a long time, I'd rather use an e-scooter. So I guess I use them like once a week, or maybe once every two weeks, it's hard to say.

R: For me it's the same, I can't say that I use it daily, but it depends, like for example if my father is visiting me, he likes to ride e-scooters so then we do it every day. But usually it's like once a month or so.

M: Okay, and what would you say are your primary reasons for using e-scooters?

R: Speed. You can get to your destination faster than on foot and it's also pretty fun. Yeah, I think entertainment is the main factor. It feels like a roller coaster.

V: I think for me it's also entertainment, as the main reason, and then just getting to your destination as fast as possible and you don't have to wait for buses, as mentioned before.

L: True.

C: Same for me, I just use it to get to my destination faster. I don't like waiting and so I use e-scooters.

M: So, by faster, you mean you replace walking or do you replace buses?

C: Waiting for buses. So for example if I have to wait like 10 minutes for the next bus, I'd rather use an e-scooter to get to my place in 10 minutes. It's also fun, we have this bridge that we use to get to our place, to our dorms and university, from the old town, and I don't know, I think it's kind of fun to ride the e-scooter on that bridge.

M: Okay. So, as I'm guessing, none of you have a personal e-scooter, you all use the shared ones, right?

All: Yes.

M: Do you feel like you are satisfied with the shared e-scooters, or would you prefer to have your own? Can you explain why you use a shared e-scooter as opposed to owning your own?

R: I would love to have a personal one, I think it's very useful. But at the same time I think the shared ones are also very convenient, because let's say if I had a personal e-scooter and I was taking a walk in the old town but then suddenly I'm like "Oh, I don't feel like walking, I need to take a scooter.", I won't have my personal one with me, and the shared ones I could get instantly from anywhere. So I think it's convenient, because you don't need to carry it around with you.

V: Yeah, we also thought of getting a personal one for a very long time now, but when we left Lithuania we realized that it's too expensive to carry it to another country. But I think for me personally it would be better to have a personal e-scooter, because the shared ones like Bolt, Bird and all those other ones do not allow you to go to all the places you want. Even in Klaipėda, we wanted to go to the beach by scooter sometimes, but it wasn't allowed because the beach was a red zone for the scooter in the app.

R: Yes, you can get fined. It's like 10 euros.

V: Yeah. But it's good to use Bolt sometimes as well, because as Revi said you can just leave it and go and you don't have to carry it around with you.

L: I would also love to have a personal e-scooter, I think it's very convenient, you can take it anywhere and I think it's cheaper if you compare the price. If you're paying for the shared e-scooter everyday then it's better to just buy your own.

C: Yes, I would also prefer to have my own, but I cannot get it since the place I'm living in isn't definite, and I don't know where I'm going to go after since I'm graduating soon. So, I don't think it's a good idea to buy a personal e-scooter right now, I prefer using the shared ones for now. But the reason why I'd love to have my personal e-scooter is because during winter time or when it gets cold they take out the shared e-scooters off the streets, so you cannot use them. Even on days when there is no snow or rain they're not available, so in this situation I'd love to have my own.

R: But I think they take it away not because of the temperature, but because when it rains or snows it can be dangerous to drive it since the road can be slippery.

C: Yeah, yeah, but in winter time we don't have snow all the time, like they take away the e-scooter in around November, but it doesn't start to snow until around January. Also about the red zones, I don't really like them as well. Because, for example, we don't have a drop off zone next to our university, it's a red zone, so you have to walk a bit far to get the e-scooter. It also means that you have to park it further away from the university and then you have to walk. Basically, there are some places that are limited by the shared e-scooter apps, so if I had my own I wouldn't have this problem.

M: Okay, good to know. So, now could you try to walk me through how your typical e-scooter ride goes? Like, from the beginning when you open up your phone to the end when you park your scooter.

R: So, usually I just order it on the app, and then usually I know the destination I want to go to, I think there was only one time where I didn't know where to go, so then I just made stops whenever I would need to check where the next turn is and continue. But that was just one time, usually I just know the route and I just go straight to my destination. The ending part is kind of annoying when you have to take a picture and position the scooter according to the app, it can be kind of complicated sometimes. But yeah, it's pretty easy, but I guess when you need to use maps to figure out where you need to go it can be quite inconvenient.

V: First when I start, I usually find an e-scooter first. I used to look at the app to see the available e-scooters, but I don't do that anymore. So when I see a scooter I scan it, I pay for it, I get on and I also have google maps always open, because the maps on the e-scooter apps can be very confusing and unclear. Then I find a zone where to park and then of course I also take a picture and leave the e-scooter.

L: My process looks similar to Vika's in a way, but I've actually never used an e-scooter alone, I was always either with someone or I was sharing a scooter with someone, so I would be standing on the same scooter with another person. So what I usually do is I talk to people who are around me and encourage them to go and take an e-scooter, then we order it, we pay for it and then we go. But I'm actually scared to use an e-scooter on my own, because I don't really trust myself, so I prefer to use it with other people.

C: So, for me is that I open the app, I look for the e-scooter, I find it and then scan it, after scanning I check the battery, and if the battery is full I press start, and after I reach my destination I park the e-scooter at the drop off zone and take a picture of the scooter and that's it. But I have never used google maps or any other navigation app while driving because I usually use e-scooters when I already know where I'm going and know all the directions.

M: So that makes me guess that you don't use a phone while driving an e-scooter?

C: Yeah, but I usually listen to music through my headphones when I drive, but apart from that I don't use my phone because I think the scooter is going so fast that it could be dangerous to use a phone.

M: And if you don't know the route to your destination, how do you approach that?

C: Oh, so when I don't know the direction, I just usually stop at every red light and then I check the map really quick to see where I am and where I need to go.

M: Okay, so I'm guessing you don't find it safe to use your phone while driving an e-scooter?

L: Yeah, I would never use my phone while driving e-scooters, I think it's going to end bad.

C: I have used it a couple of times while driving, for example to take a picture, but it's only for a split second, so I don't think it's safe.

V: I know that some scooters, mostly the personal ones, have phone handles on them and you can place your phone. So I can share my experience using a bicycle, it's very dangerous when you ride with one hand and hold your phone in the other, but when I ride my bike I have a phone handle in front of me so I have a map open on my phone and it feels pretty safe. So I guess it would probably be the same for e-scooters.

R: I actually feel safe holding the phone with one hand. I only find it difficult when I want to speed up, but other than that I feel like I can use a phone.

M: And what applications do you usually use while driving?

R: Google maps, always.

M: Okay. So, if there was a mobile application for navigation tailored specifically to e-scooters, what kind of features would you expect to see? What do you think is the most important?

V: I guess for me it would be that it would show the roads that are not highways, like where there are no cars but you can still legally drive there. Because for example in Porto I have no idea where I can drive because I see everyone using e-scooters on highways along with cars and I wish to know about the roads that I could take my scooter and drive along with people on the sidewalk.

L: For me it's important for the application to be as easy as possible to use because sometimes it can be very confusing, but as user friendly as possible. Also, for example Bolt makes you pay before

you use the e-scooter, but it would be nice if the app had the possibility to pay afterwards. But that's my subjective preference.

R: I think aside from showing the route and what road you can go, I would also love to know where I can leave the e-scooter, like the drop off zones, and what are the red zones as well. Just to know where I can go and where I can park. But I think most helpful would be if it was possible to insert like a little screen on the scooter itself, so you don't have to hold the phone.

C: Yeah, I agree with everything that was said, I also wanted to say that a screen on the scooter with a small map would be nice, and since it's really difficult to use the phone, we can use headphones so maybe the app could have an option to use audio to inform about the directions, also it could start beeping or just indicating when you drive into the red zone.

M: Okay. Have any of you ever used "Waze"? The navigation app for cars?

All: No.

M: Oh, okay.

R: I don't know if this is considered using, but I remember I was on a road trip and my girlfriend's father was driving us, and he was using "Waze". I saw him using it, and I thought the signs and indications that the app gives out is pretty convenient. Maybe even more convenient than "Google Maps", but I wouldn't use it for a scooter, I think.

M: I see. Because in "Waze" there is an option to report hazards, so, for example, if there is road construction you can just report it and other users would see it. Do you think this type of feature would be useful to a scooter application?

R: I think it would be nice. I think it would be useful to see which areas are crowded, like if you are taking your scooter on the pavement, where people are also walking, so if there is an event or something like that happening in a certain area and there is a lot of people, it would be useful to mention that to make sure you avoid any accidents.

V: I agree that would be nice to know, but I think me, as a user personally, I would not stop to report it, because I usually just want to get from point A to point B.

L: I would report it.

M: Alright. Can you try to describe to me how you would imagine the app to look like? Like, for example the design and the colors.

V: I imagine it would have very simple colors, like “Google Maps” for example, it has just blue and white. I would also think it should be a 2D view of the map, not like 3D maps that some apps like to use now. Also, nothing too noisy, so just only the essentials, which is basically just the road. And maybe the roads that I am not allowed to take highlighted in a very bright red color. But basically very simple, minimalistic design.

L: Yeah, I definitely agree. I also see it as very minimalistic and simple.

R: I think I imagine the opposite of Vika and Lile. The first thing that popped into my head was like a game, with colorful roads. I’d want something entertaining and animated, like something fun. Cause in my opinion, if it’s more like a game, then you can follow the map and it would be more entertaining.

C: I also like Revi’s idea, I would also like to have an app that would be very colorful. Maybe something like pastel colors and have the buildings in an illustrative style, since most people who use scooters are probably using it to reach some kind of building, so showing the buildings in a cute and appealing design would attract more people to use the app, I think. Also, I don’t know about the other places in Europe, but here in Lithuania and the country I’m from, the majority of people who use e-scooters are teenagers and young adults, so I think this type of cute and colorful style would attract them to use e-scooters more.

M: Okay, so you imagine the app to be very colorful and gamified. Would you feel safe using this app while driving an e-scooter?

C: Oh, I wouldn’t use it while driving. I would just use it to search up the route for the destination.

L: Actually, now that I think about it, even though I love minimalism in apps, but I would like to have some sort of avatar that would show up as me on the road while using the app.

C: Yeah, I think an avatar would also be a great addition and would attract even more teenagers and kids to use the app and e-scooters.

M: I see. Okay, so now if this app were to come to life, how would you prefer to receive information from the app?

R: I guess I imagine it to be in the same way as car navigations work, like a sound to catch your attention and then just a message on the screen. Also if the message would be read out with a voice it would also be nice, since you wouldn’t have to look down at the screen. Or, I guess if you want to have your phone on mute, maybe like flashing to get your attention, since you’re looking ahead

at the road, not on the screen, so if the phone flashes then you will pay attention to what's going to pop up on the screen.

L: For me sound would be way better. Because flashing colors I would definitely get-

R: What if you were deaf or hard of hearing?

L: I mean, I'm talking about myself. But the flashing colors could also be dangerous for some people. I think sound and pop-up notification could be useful.

R: I think it would be useful to have an option to choose how you like to receive the notifications. You can choose either sound and voice, or you can choose the screen flashing one or something.

V: I would like the voice or some sound indications, because I don't want to be looking down to see if there's some hazards or something.

C: Yeah, I agree with Vika, but I also agree with Revi, I think it would be great if people could choose how they want to get the information.

M: Alright, and what kind of information do you think should be shown and prioritized? And in contrast, what kind of information do you think is unnecessary and would only distract the user?

C: Okay, so when have a route to your destination and you're driving an e-scooter, if while driving the app finds a faster or more convenient route you could take instead, I think it would be nice if it informed you about that. Also, I think regarding voice and sound, the sounds shouldn't be very loud and sudden as it can scare you while driving. Also, if you're about to drive through a dangerous district in the city, I think it would be nice if the app let you know that the area isn't very safe before you get to it.

V: If you're going to some touristic area or just a place where's there's commonly a lot of people, it would be nice to know about the amount of people there and show alternative routes to avoid the traffic and crowds. Also, it would be nice if it would notify if I'm driving on a road that I'm not allowed to drive on.

L: Yeah, I agree with everything that was shared.

R: I also wanted to say that, I don't know if I'm stretching too far, but if I have to cross the roads and the app would tell me if the next intersection is a red or a green light. Because sometimes I cannot see the traffic light or I'm just too lazy to look up, so I think it would be cool if the app could connect to the traffic light system and tell me what light is ahead and if I can drive or not.

M: Okay, thank you. So, since the focus group is coming to an end, I want to ask if anyone else has any questions or something they'd like to share or add?

All: No, not really.

M: Okay. So if no one else has nothing to add, I just want to say thank you for participating in the focus group. Your insights have been very interesting and useful and have provided so much help for my thesis and the application prototype. If you have any further questions, thoughts, or concerns after today's session, please don't hesitate to reach out. Before we part ways, I want to ask if it would be possible to meet up again after a few weeks? I'll let you know the details later, but the next time we meet we might already discuss the first version of the prototype.

All: Yeah, sounds good.

M: Okay, that's great. For now, thank you once again and I hope we talk again soon. Have a nice day!

## **ANNEX G – Interview with Expert #1 Transcript**

### **Interview Transcript**

Date: 2024-05-24

Duration: 1 hour 10 minutes

Interviewer: Mingailè (M)

Interviewee: Expert #1 (O)

M: Hello, and thank you so much for agreeing to speak with me today. My name is Mingailè, and I'm a Master's student at University of Porto, Faculty of engineering, and I'm working on my thesis titled 'A Multimedia Design Approach for On-the-Go E-Scooter Applications.' In short, my thesis focuses on developing a navigation application specifically designed for e-scooter users, so my research aims to explore how these e-scooter navigation apps can be designed and integrated into urban transportation systems to enhance safety, efficiency, and accessibility for all users. Your extensive research on urban mobility and micromobility, has been incredibly insightful for understanding the complexities of this mode of transportation within urban environments. So, today, I'd like to discuss how your knowledge can inform the development of e-scooter navigation apps, especially in enhancing safety and efficiency within urban transportation systems. Before we begin, I'd also like to inform you that this interview will be recorded strictly for research purposes. Your privacy and confidentiality are of most importance, and your personal information will not be disclosed. I hope that is okay?

O: Yes, yes, of course.

M: Okay, that's great. So, to start off, maybe you could briefly introduce yourself? So, let's say, your age, academic background, your PhD thesis theme?

O: Yeah, of course, thank you. My name is *[Expert #1]*, I'm from Ukraine and I got my bachelor's and master's degrees in Ukraine, and my specialization is transport technologies. In my Master's degree I was participating in an Erasmus program and thanks to that I met my supervisor, and now I'm a PhD student in the University of Rome Tor Vergata in Italy. My thesis topic is more or less about the technologies, the emerging information and communication technologies that could help urban logistics, urban transport for optimization, for reducing the externalities, the optimization of routes and also I touch on some fields like micromobility, the railway. So now I'm a second year

PhD student and I hope I'm on the right track and I will finish my thesis on time. Also, I don't know if this is relevant, but I also teach lectures at my University and I also use software for the transport network visualization and simulation. In the last months I've been focusing on the end consumer purchase behavior, which means how to receive purchases which were made online, but nevertheless, micromobility is still one of my main topics. Also, about few months ago we published a paper about micromobility but more focused on accidents involving micromobility devices. So, I'd like to ask in which micromobility device you are focused on?

M: For my thesis, the main focus is e-scooters. This application is supposed to be for e-scooters specifically, but I also think that bicycles and e-scooters are a bit similar in a way, so I think that if you have any insight from the perspective of bicycles, I think that would also be very helpful.

O: Okay. The idea is, for example, bicycles are divided into two types: there are personally owned bicycles and shared bicycles. They are very different experiences, simply because, for example, on shared bicycles it is possible to put a GPS system in them, but for personal bicycles it's more complicated, since you have to request data from the user. From my perspective, for navigation, I can say that, for example, if we analyze the accidents, we can understand the black spots of the accidents involved with e-scooters and other micromobility devices, so in this case, a navigation system could help to create more accurate solutions for that. But I don't know, maybe you have some specific questions you'd like to ask me?

M: Yes, of course, I have some questions prepared. So, first we can start off with the general topic of e-scooters and then we can get into the application. Can you briefly describe how do you perceive the role of e-scooters in enhancing urban mobility?

O: Okay, the role of e-scooters. I think there's a few ways to describe their role. Because for example, now I live in Rome, and it's a super touristic city. So, the tourists use e-scooters everywhere, because the city center of Rome is a *ZTL* zone, which means the roads are closed off for certain periods for cars and other personal vehicles. Another thing is narrow streets, like in some cases a car just is not able to pass the street, so in that case, tourists take e-scooters. And this is a challenge, firstly because sometimes they don't pay attention to the rules and laws. So, I think this is a big problem for tourists. But, on the other hand, users who live in the city, who need to commute from home to the metro line or directly to work, also frequently use e-scooters. So from this point of view, it's a completely different behavior compared to tourists, because they can also use their personal e-scooters, so it comes with its own behavior and its own risks. So, basically, I think for the city center, e-scooters are very useful for tourists just to get around, but I think we

have to provide more recommendations about how to safely use e-scooters, and maybe even reinforce some form of punishment for breaking the rules. Let's say two people use one e-scooter, or use a scooter without helmets, and of course it's their responsibility, but on the other hand we have a lot of accidents which cause a problem not only for e-scooter users, but also for traffic and other pedestrians. Also, in France and Northern Europe, they use a lot of micromobility, but strictly on bike lanes, which I think is a very interesting experience and interesting to analyze. So, I think scooters for the urban mobility is a very fresh and popular topic, but we also face a lot of challenges because of that.

M: Okay, thank you. I know that you've done research on micromobility and traffic and accidents, so could you tell me if you've noticed any significant impacts of e-scooters on traffic specifically?

O: We divided the micromobility to classes and we have noticed that e-scooters have the highest percentage of accidents, simply because there are more of them around the city. Also, I can say that we have additional lanes for bicycles and e-scooters, so they have different speed limits and different regulations. Also, before the analysis of the accidents, we analyzed the quantity of the e-scooters and bikes. We went to apps like Lime, Uber, and other similar apps in which you can rent a shared e-scooter, and in the app you can see where most e-scooters are distributed. And, basically, there's a correlation between the number of e-scooters in a certain place and the number of accidents. Also, I wanted to say that there are different rules for different micromobility devices, as well as different regulations in different countries. For example, in some countries you can use an e-scooter on the sidewalk, but in other you can only use it on the road. So, it really depends on the country and city and their laws and regulations. But, coming back to your question, I can say that I haven't noticed any impact, because it's simply difficult to analyze, since in the city center in Rome, the *ZTL* zone, e-scooters are the primary use of transportation in the city center, so you can't really say that it's congested just because of e-scooters. The safety in the city center because of the e-scooters is another topic, because the pedestrians and the e-scooters have a lot of obstacles. But yeah, for traffic, we have additional lanes for e-scooters and bikes, so the impact on traffic is very minimal. Also, another problem arises when an e-scooter has to cross a street, and it is not sure how they should properly do it. Is it supposed to be by walking, like a pedestrian, or by driving along with cars. Maybe it's not that correlated to traffic, but, for example, they could start off by walking and then at some point decide to change to driving on the road, so in this case it could cause some problems. I actually haven't analyzed this topic that much, but I think it's an open question.

M: Okay. Based on your studies, can e-scooters be effectively integrated with public transportation systems to enhance urban mobility?

O: I think it depends on the city, the size of the city. Because, like I said, sometimes I can see instances where people take an e-scooter to go to the metro station, simply because they don't want to walk the distance. And also, I don't know, maybe it's just my opinion, but in Rome we have a lot of uphill and downhill streets, so it could be difficult to go these paths on foot. But, for example in Rome, I think e-scooters could be integrated into public transportation systems. Maybe not for the city center, but for the other districts that are connected with the metro.

M: Can you identify any key factors that increase or decrease this integration?

O: Okay. The one thing is the recommendation about where these devices can and cannot go. Because, for example, if between my home and the metro there is a large street just for pedestrians, and it's also available for bicycles, but I'm not sure if I should go past that street because there is a lot of people. So, if I take an e-scooter, I should be certain which routes are safest for me and other people, where there's not a lot of pedestrians. Another thing is the designated drop-off spots of e-scooters. Because, near my home I don't have a drop-off zone, but in the city center there's loads of them. So, in this case, it's important to know the potential number of people who'd be willing to use e-scooters in that area. Also, for example, if it's their personal e-scooter, they can come to the public transport stop, but then we'd need to provide some place for them to store their e-scooters. So, I think good organization of these places has to be done.

M: Okay. I guess now we can pivot towards questions revolving more around the applications now if that's okay.

O: Yes, sure.

M: In your opinion, do you think navigation apps could be used while riding an e-scooter, or are there significant safety concerns that outweigh the benefits?

O: Who can use this navigation system? Is it for users or for operator?

M: For users. It's something similar to Google Maps, for example. You just type in the destination you want to go to, and you see the route and just go. Some e-scooters have handles where you can put your phone in, so it's just an app that show you the route to your destination. Do you think that's a safe option or do you think it's too much of a distraction while riding an e-scooter?

O: Okay. May I ask one more question?

M: Yes, of course.

O: Okay, for example, I'm a user in the city center, I want to take a scooter, I can check where it is, but what about other users, can I see where they are on the map?

M: I actually haven't considered that yet, but the idea of the app is, like you said, I can check for available e-scooters, I can see where the nearest drop-off spots are, there's also indications of hazards on the road. So, as I said, it's just basically a Google Maps and Waze type of application, just specifically designed for e-scooters.

O: Okay, one more question. Is the study area in Porto?

M: Yeah, more or less.

O: Okay, in Porto do you use e-scooters on the road along with cars, or can you go on sidewalks?

M: It's on the road. But I have done a few focus groups with users from around Europe, so in some of their countries they are allowed to ride on the sidewalk.

O: I see. Because I'd like to imagine how the app looks and operates first.

M: Actually, if you'd like, I can show you the prototype I'm working on for the app, just to give you an image on how it would look like.

O: Yeah, that would be great.

[App presentation]

O: I see, can you remind me what the question was?

M: Yes, of course. So, in your opinion, do you think navigation apps could be used while riding an e-scooter, or are there significant safety concerns that outweigh the benefits?

O: I think it could be useful, especially if you know if there is congestion or any accidents on your way, you can choose an another route. Just one thing about the hazard warning regarding the crowded spaces. It's essentially private information about people, so there might be some issues getting information about that. Another question, do you have highways in Porto?

M: Yes.

O: And can e-scooters ride on these highways?

M: No.

O: Okay. But I think since e-scooter laws vary between cities and countries, and if your app is supposed to be for all cities and not just Porto, it's important to show the traffic regulations for the city you're using it in. Also, what about personal scooters? Can I still use this app if I don't use a shared e-scooter?

M: Yeah, it's a very interesting point. Most people I've talked to mainly used shared e-scooters, but I did talk to some who have their personal scooters, so they suggested that the app would have two modes for shared e-scooters and personal e-scooters. Because some features, like the scanning for nearby available scooters or the drop-off zones aren't really necessary for users who have their own scooters, but they still thought that the app would be useful for navigation, since most navigation apps are focused on cars, and so the calculated routes are usually on roads that only cars can go on, and they don't really show the most efficient route on an e-scooter.

O: Yeah, that's true.

M: Okay, another question I have is related to something we've discussed previously. So, considering the safety challenges with micromobility that you've identified in your study, such as inexperienced users and unclear regulations, what features should this e-scooter navigation app incorporate to improve safety and comply with regulatory changes?

O: I think, I see that sometimes we have some recommendations but it's up for people to decide to follow them or not. But the problem is it's not just their life and their health, for example pedestrians who are walking are also in danger. So, how can we punish or what do we have to do with people who don't follow the regulations? Let's say, two people are riding one scooter and the obstacle is pedestrians. Who is responsible for that? the operator of these e-scooters, first driver, second driver, pedestrian? And this is a real question because it's difficult to understand. In some cases, children can use e-scooters, but we can't really punish children. We have to provide not just recommendations, but we have to correlate them with the law, to discuss with the government and administration, because, for example, if an e-scooter can be driven on the road with cars, there needs to be strict regulations for that. This is really an open question, because the recommendations can easily be ignored and people aren't really punished for breaking rules, for example multiple people using one e-scooter. I think there needs to be a clear understanding what the restrictions and the laws are. But, in my opinion, I'm not sure if it works everywhere, but an additional lane for bikes and e-scooters that have a maximum of 35 km/h speed would resolve a lot of problems. I think it would decrease the number of accidents. Also I think it is very important

for users to wear helmets, but you can't really force them to wear helmets, so that is another problem regarding safety.

M: Okay. I have another question related to safety, actually. In your study, you found that 'side collisions' and 'collisions with obstacles' are common accidents involving micromobility devices, so do you think there is a way that this application I'm doing can be designed to help users avoid these risks?

O: Yeah, I think you can put the black spots, like for example analyze the accidents, especially the ones who involve micromobility devices, and know in which areas of the city are more dangerous for e-scooters and you can notify the users that they need to pay closer attention in that specific area. I think it would be useful. Also, for example, if the weather, like it's raining or it's foggy, then the app can warn about the weather and that it's better to avoid some areas, like the river where there's more fog and you can't see far out because of it. Maybe also this app can send out notifications reminding of safety regulations, like putting on your helmet and reminding that it's one person per scooter. Maybe it can be annoying for users, but I think it's important to remind them about this. Also notifications about weather, or peak traffic hours. Another thing you could add to your app is notify users how many scooters the nearest e-scooter parking spot has, so they wouldn't have to go far looking for e-scooters. Of course, this isn't about safety, but I'm just thinking of some ideas you could add to your app. Also, maybe it's useful for users to create accounts on this application. Did you think about that?

M: I have considered that as an option, so the users could keep track of their saved locations or something like that. Some users from my focus groups that they don't think that's a necessity, but I think having accounts and user profiles could be useful.

O: Okay, because I'm thinking about how you could use this data. Because, for example, if it's a registered account and they put information about themselves, you can understand what people mainly use e-scooters and where their usual destinations are, and it's possible to distribute e-scooters according to that. Also, do you know how in Google Maps you can choose not to depart immediately, but you're allowed to plan your trip, so I think that could also be useful.

M: Okay, a few more questions left before we wrap up. So, as we discussed previously, we talked about integrating micromobility with public transportation. So, do you have any ideas what kind of functionalities could this app include to make this integration more seamless?

O: Do you know the application Moovit?

M: I have heard of it, I think.

O: This application is about public transport, especially, for example, I personally use this for buses, and it shows precise times when the buses will arrive. So, I think if these apps could be combined, you could create your route, for example from home to metro station, by e-scooter, then it would show the route with metro or bus. It could show more accurate times when you need to leave your home to get to the metro or bus stop in time. So, basically, if you have data about public transport, you can compare and know precise times when you need to leave and when you'll arrive.

M: Alright. Do you think that e-scooter navigation apps can play a significant role in supporting the long-term sustainability of e-scooters?

O: Yes, I think so. For example, if you have this data from your app, and after a few years you can analyze the correlation between the movements and accidents, and like which areas are mostly used by e-scooters, where users prefer to go to avoid cars or traffic, or the opposite – which areas e-scooter uses usually avoid. And based on this you can make adjustments, for example, analyze the spots where people can take e-scooters, then the main roads and then you can make restrictions for example about speed limits and then you can analyze what changed in the users' behavior and the transport network, more specifically the e-scooter network.

M: Okay. And, for the last question, as someone deeply involved in the study of urban mobility, what are your personal hopes and concerns for the future of e-scooters and micromobility in general?

O: I think, once again, it really depends on the country and city. Because, for example, if we compare Rome, where I'm studying right now, and Kharkiv, the city I come from, it's completely different. The behavior of using micromobility devices is completely different. Here in Rome, the tourists and the workers are the most common users, but in my city we mostly use them for fun, so it's mainly for leisure purposes. Based on these different points of view, if you want to include e-scooters in traffic, like the transport network, it's an another point of view, because you have to analyze and recommend restrictions. Basically, the idea is that based on this emerging device, we really need a few years to collect data and based on the results we can provide recommendations and rules. Maybe it's different for each city, so if we could do these micro simulations, if the authorities can provide the appropriate rules, I think it could be a very innovative device. Because an e-scooter is small so it's appropriate for narrow streets and you don't have to have extensive knowledge to operate it. But I think basic knowledge about transport networks and how the system

works in general could enhance safe behavior. I think, in our condition in cities and city centers, especially places where there are restrictions for cars, e-scooters are a great option to get from one place to another. For tourists it's also very useful, because the city center is very large and metros and other public transport can be complicated sometimes. Of course, we also have a lot of challenges regarding safety in implementing e-scooters into the traffic network, but we have to spend a few years organizing and figure out the best way to implement them. But I think that e-scooters are the future.

M: Alright, thank you so much! I think we're done with the questions. Before we finish this off, do you have any additional comments or questions?

O: No, not really.

M: Okay, so, I want to express my sincere gratitude for taking the time to speak with me today. Your insights have been incredibly valuable and will significantly enrich my thesis. The depth of your expertise in micromobility has provided me with a broader perspective on the challenges and opportunities for e-scooter navigation apps. I truly appreciate your willingness to share your knowledge and help guide my research.

O: Thank you for having me.

## ANNEX H – Interview with Expert #2 Transcript

### Interview Transcript

Date: 2024-05-10

Duration: 40 minutes

Interviewer: Mingailè (M)

Interviewee: Expert #2 (G)

M: Good afternoon. First of all, thank you so much for agreeing to speak with me today. My name is Mingailè, and I'm a Master's student at FEUP, working on my thesis titled 'A Multimedia Design Approach for On-the-Go E-scooter Applications'. In short, my thesis focuses on developing an app specifically designed for e-scooter users, and my research aims to explore how these navigation apps for e-scooters can be designed and integrated into urban transportation systems to enhance safety, efficiency and accessibility for all users. I think that your extensive research on urban mobility and micromobility, particularly regarding e-scooters, is incredibly insightful for understanding the complexities for this mode of transportation. So today I'd like to discuss how your knowledge can inform the development of e-scooter navigation apps, specifically within the urban transportation systems and enhancing safety and efficiency. So, before we start, I'd like to inform you that I will be recording this interview strictly for research purposes. Your privacy and confidentiality are of most importance, so no personal information will not be disclosed. I hope that is okay?

G: Yes.

M: Okay, so I would like to start off the interview by asking you to briefly introduce yourself. So, like age, academic background and your PhD thesis topic.

G: Okay, so my name is *[expert #2]* and I'm doing my PhD here in Portugal as well, in university of Minho. My field of study is territorial planning and I'm focusing my PhD research in the parts of shared e-scooters in urban environment. And we are doing a case study here in Braga, where we have two companies now providing the service. I also did my master's here, in urban engineering, I worked with bicycles, so always in micromobility. I researched about cycle highways, which are kind of roads for bicycles in order to displace from one city to another. And then now I'm looking

more into e-scooters but I've always been in the micromobility area. But yeah, I'm a civil engineer.

M: Okay, that's good to know. I guess I'll just get right into the questions, so could you first try to explain how do you perceive the role of e-scooters in enhancing urban mobility?

G: Okay. For me it's a trick question, because it's kind of uncertain how shared e-scooters are going to improve or even make the urban mobility worse. I think we need more studies and more improvement in regulations and also influencing the use of micromobility. I've seen a lot of studies even from the results we have here in Braga, we see that yes, some car trips can be replaced by shared e-scooters, short distance trips. And most people mostly likely to replace their leisure trips, not the commute ones. But it's interesting, even though for example we cannot have a lot of scooters on the streets during peak hours during the week, but on the weekends we can have a lot more e-scooter trips for people that go to the supermarket or go to their leisure spots. So even though we can have some modern shift here, right now it's very minimum, so more improvements need to be done. People still feel very scared on using shared e-scooters in Braga and all around the world and the regulation's a big part of it. People don't know where to use e-scooters, how to use e-scooters and even the whole environment, even though people are very used to bikes that have been around for a long time, shared e-scooters are very new, and even though the government sometimes say that people should use e-scooters as they use bicycles in the terms of legislation, people still don't know that and they don't know how to use that, they don't know that they have to ride e-scooters on the streets and they mostly use it on the sidewalks because they don't feel safe on the streets because of the traffic and because of the high speeds. So, for now, what I see and what I expect for the future and how I see the shared e-scooters involved in micromobility is that more improvements and more studies need to be done in order to increase the safety for the users. If we don't increase the safety, people are not going to use it as we want to, to replace the car trips, because they just feel unsafe and I think that of course some other problems need to be faced, like for example the prices for scooters. People still pay high prices for it. Here in Braga, for example, sometimes an Uber or a Lyft is cheaper than to use an e-scooter. So people, when they have to look for prices and for time travel, they still choose other modes of transportation over e-scooters. So there are some points that still need to be worked on in the future so scooters could be used more in cities. I don't know if I answered this correctly, but I think that for me, as I'm studying this right now, these are my main points. I see that people are afraid of scooters and they're unwilling to use e-scooters. But I think they are promising for the future.

M: I think so too. In your research, have you identified any significant impacts of e-scooters on traffic, specifically?

G: Here in Braga, in the case study we're doing, we haven't studied this data. We know the number of trips, we know the number of vehicles, they are being pretty much used by young people, but the impacts that they have on the traffic, I couldn't say for now. And also about the accidents, we're trying to gather data on the accidents, but we just couldn't, because in the hospitals they do not make the acquaintance for the e-scooters if people go there injured. So it's still a bit difficult for us to identify how scooters are in traffic. But I could add to this question and talk about the routes people take? I don't know if it's valuable or included.

M: Yes, of course.

G: Okay, yes, because we have the maps here where e-scooters are used and most of the traffic of e-scooters are in the streets where the speed limit is lower, so the traffic usually happens when we have some cycle lanes, which in Braga is just in a few spots in the city and the cycle lanes are not connected. So the traffic are mostly for the cycle lanes, and where the speed limit for cars is lower. And of course, the service is restricted, so people cannot ride e-scooters on arterial roads, but here in the city center scooters are mostly used to connect from the city center to the university campus and to the mall, which are basically in the same area. The scooters are almost always used on the streets where the maximum vehicle speed is lower.

M: Okay, thank you. Based on your studies, can e-scooters be effectively integrated with public transportation systems to enhance urban mobility?

G: Yes. That's a case we've studied. We are using some surveys in my study now, and in the first survey we did in Braga, we asked people if they were willing to use shared e-scooters if they were available in bus stops, since the only public transport we have here in Braga is the bus. And people said they were willing to use it for the first and last mile of the trip, just to go from their home to the bus stop. Even though we didn't ask about the ticket, because people would still have to pay separately for the scooter ride to the bus stop and then pay the ticket for the bus, people were still willing to connect e-scooter and buses.

M: Okay, and have you identified any key factors that either facilitate or maybe even hinder this integration?

G: The location of the scooters, the parking spots for the e-scooters. Here in Braga, you get rewards if you park the scooter in the designated parking spots they have for e-scooters, even

though they are free floating here, people are still advised to park in the specific spots that the municipality did in the city. So, one of the factors would be if there were more scooters available near the bus stops and if these parking spots were present near the bus stops.

M: And were you able to identify any instances where e-scooters have replaced cars for certain types of trips?

G: Yes, but mostly for leisure trips. For commuting trips, people are not willing to use e-scooters mostly because here in Braga we have this bad thing that most trips are made by car, so people here basically use cars for their daily displacements and people still take their cars for their daily trips, like commuting to work and school. They think it is the best option because they can have their own schedule. They think that with e-scooters, like if it rains or if they cannot get an e-scooter right away when they leave home, it would be difficult to get to work or school. So most trips that replace cars are for leisure purposes. On the weekends most of the trips here in Braga are made from Friday to Sunday. We also have a peak of trips on Tuesday, but we haven't identified what's the motive for the high number of trips on that day. But, basically people mostly use e-scooters on the weekends, so it's probably not to go to work.

M: I see. So, now we're going to shift the questions more towards the app. So the first question I have for you is: in your opinion, should navigation apps be used while riding e-scooters, or do you think there are significant safety concerns that outweigh the benefits?

G: Yes, there are. I don't think people should use any app while riding an e-scooter, since a simple touch of anything could make people fall, so I don't think it's safe for people to drive an e-scooter with one hand while holding a phone in the other hand to look at the app.

M: That makes sense. But I have done a focus group and spoken with e-scooter users, and some have said that there are phone handles on the front of the scooter, like on the steering wheel. In that case, do you think it would be safer or do you think it still causes a lot of safety concerns?

G: I think it would be safer, just because people would have both of their hands on the steering wheel, but the perception of the transit and the environment around, if people focus on their phones for anything, if they have to check the route or if a notification comes in and they just don't focus on the transit anymore, so I still think people shouldn't be allowed to use their phones while riding e-scooters. They should plan their trips before, know where they want to go and more or less the route on how to get there, but I don't think it's safe to use during the ride. As it is not safe for cars and for other modes of transport, because we lose focus on the transit.

M: Okay. So, I've looked through some of your articles that you wrote and one of them highlighted significant safety concerns among e-scooter users, particularly regarding head injury and illegal parking. Do you think navigation apps could somehow contribute to mitigating these risks and enhancing overall safety in e-scooters and urban environments?

G: You mean navigation apps for e-scooters, where people could plan their trips?

M: Yes.

G: Yes, I think so. One of the things I was thinking and I have spoken to some people that think, and I also think this, that this would greatly improve e-scooter usage, if people could use the app to plan their trips in advance, for example, as we have in Uber or in Google Maps, where you can put in a location you want to go to, and for e-scooters it would be the same, people would get an e-scooter and say "Okay, I want to get to point B" and the app would give you the route, the price of the trip, I think that's very important for people to consider if they want to get that mode or not, and, for example, would advise for a specific parking spot that is near to their destination. In this case, I think it would decrease the number of injuries, because, if I'm not wrong, the head injuries were related to people that were parking the e-scooters improperly on the sidewalk, so people would trip on the e-scooter and fall. So, if the e-scooters are properly parked in the dedicated parking spots, then they wouldn't be on the sidewalks and it would be safer.

M: Okay. So, once again, in your studies, you observed usage patterns around city centers, so what strategies could this navigation app implement to reduce e-scooter congestion in high traffic areas?

G: Well, the problem in shared e-scooter usage in specific areas of the city is because the e-scooters are deployed there. Here in Braga e-scooters can only be used in certain areas of the city. We have 37 parishes, and the scooters are allowed in only 8 parishes, which are in the very center of the city. It's in the city center, near the university, and the main malls and supermarkets, so for me the biggest problem for the high usage only in this area, where most of the cars are and most of the public transport is, is just because people can only use e-scooters in that area, because they are forced to. They cannot go anywhere else because the scooter is going to stop. But, considering if they can plan their route in that area and in the app they have real-time traffic information, they could plan their trips for routes that are less congested and then maybe even if the person wants to use the car, they could see that some roads or some specific part of the city is congested and they can take the e-scooter and they can go through another route that's better and safer, so probably this would help.

M: Okay. Given the role of e-scooter in intermodal travel, what features in these navigation apps for e-scooters are critical for facilitating seamless transitions between e-scooters and other modes of transport?

G: I think everything goes to the fact that people could plan their trips there. If in the app they have all the information from the other modes of transport and people could have the information, for example, taking consideration the example in Braga, where we only have buses. If people could have an app where they could have the information about the time it takes to get to the bus stop and when the bus arrives, then they could plan when they need to leave their house, take an e-scooter to go to the bus stop and arrive there on time so they could take the bus. I think the time planning of the trip would allow people to choose better between connecting all the modes of transportation available.

M: And considering your research on the promotion of equity and sustainability, what role do you see for e-scooter navigation apps in supporting the long-term sustainability of e-scooters in urban transportation networks?

G: For equity, I think that the main results that we got is that scooters are mostly used by one specific group of people, and we have the basic profile of e-scooter users. And for the app, to improve equity, I think that giving specific information for specific groups, for example, if you join the app and state that you are a person with low income then you can get specific rewards for that or specific fares for using e-scooters, maybe this would allow for more people to use them. Or, for example, you state that you are a female, a woman, then you can get specific route details that are safer or that can be connected to the places that you go more often. And for sustainability, I think the rewards for people that would use more e-scooters instead of cars and people would shift their mode of transport from more polluting ones to e-scooters, maybe the app could give them rewards or free trips if they reach some certain kilometers traveled. I think this would make people more willing to use shared e-scooters instead of more polluting modes. And, of course, depending on your profile, you could get different rewards. It's just to make it fair for everyone, because it's not equality, but it's equity, like having an app that flows differently for different kind of people based on their needs. This would allow for more people to use it in a safer way and in a more comfortable way.

M: Okay, thank you. And, as someone deeply involved in the study of urban mobility, what are your personal hopes and concerns for the future of micromobility and e-scooters?

G: I hope that in the future they are more used. I think they need to be more incorporated in the mobility system of the city. Talking about micromobility in general, bicycles are here to stay and they have been here for a long time, people are used to it, people use it, and there are a lot of studies in cities that have experience in managing bicycle schemes, but for e-scooters it's a little bit more complicated. They are very new, they have just started being deployed in cities in 2017 in The United States, and it's still a mystery for people, if they're going to work or not. I've been studying this for 5 years and I still don't know the answer if they're going to really stay. People are trying to make them stay. Comparing like the free floating electric bicycles, to the free floating electric scooters, the way they are used nowadays, it's not very sustainable, and improvements still need to be made. Even from the beginning, from the production and the design of the vehicle itself, it needs to have a longer life cycle. Because nowadays the e-scooters last from 6 months to 1 year, and in the beginning they would last only for 3 months, so that's absurd, if you have a mode of transport that lasts just for 3 months then it would just result in a lot of garbage and the whole structure of the vehicle goes to the trash. But, improvements have been made and the vehicle's life span is increasing. If people can have some more specific regulations and specific treatment for the shared e-scooters to be more safe and more equitable, maybe in the future they will be used more and they can get us to shift to a more sustainable urban environment. I think the critical issue now is the e-scooters, because bikes have already been established, so I hope that with e-scooters we can have the vehicle, the service, the companies and the use included into one package so it's better, it's safer and it lasts longer, so then we'll have a more sustainable mode of transport for everyone. And of course, it doesn't pollute when you ride it so if you use it then it's already being sustainable, but some improvements still need to be made in these other areas. If we have a global view for the e-scooters, the zero emission trips, the reduce of emissions, the production and the treatment of the battery, the increasing of the life span, the sustainability will increase and then we're going to have a more sustainable and efficient mode of transport.

M: Okay. So, I think we're done with the questions. So, before we close this up, do you have any additional comments or questions?

G: I don't know. I still believe that e-scooters can be a good option. I think that some more improvements need to be made. We have cars that people use massively nowadays, and it started with no one believing in them, so maybe it's going to be the same with e-scooters. They are still new, we don't know a lot of things about them, so maybe in the future we're going to see more e-scooters on the streets than cars.

M: Yes, that would be nice.

G: Also, there's something I just remembered. If in the app people could have some metrics, for example, it would show how much time they've been using e-scooters and how many kilometers they've travelled, and how much Co2 they've saved by choosing e-scooters instead of cars, or any other metric that people would be interested to see, so they would know that they are doing a great job and helping the environment. I think it would be interesting to have that kind of information in the app so people would be more interested in reaching the goals, like that gamification process with some goals for their Co2 emissions or for, I don't know, something like that. But basically, some metrics that people would find interesting to see there and to just know that they are doing a great job. Maybe this would help to make people more willing to use e-scooters and to promote a better environment.

M: Okay, thank you, I will definitely look into that. I want to express my sincere gratitude for taking the time to speak with me today. Your insights have been incredibly valuable and will significantly enrich my thesis. The depth of your expertise in urban mobility and micromobility has provided me with a broader perspective on the challenges and opportunities for e-scooter navigation apps. I truly appreciate your willingness to share your knowledge and help guide my research.

G: Of course, I hope I helped you with my answers.

M: Yes, thank you, you've helped me quite a lot. I hope you have a great day.

# ANNEX I - Figma Prototype

