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Developing personas to improve understanding of users' needs in digital mobility: An experience of the DIGNITY project in the Barcelona Metropolitan Area

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Abstract

This paper contributes to the understanding of the end users' needs and capabilities in digital mobility by presenting a set of personas developed using data from a population-representative survey conducted among 601 Barcelona Metropolitan Area (BMA) residents. The questionnaires were carried out within the framework of the DIGNITY project. The results show that large parts of the population cannot access digital technologies or lack the skills required to use them effectively. As a result, they are not able to take advantage of many digital mobility solutions. The personas in this paper thus present important information on the diversity of potential users, in a way that designers and other stakeholders can find inspiring. This can help them to create inclusive mobility ecosystem, that fit the users' needs better, resulting in more people being able to use the solutions.

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1. Introduction

In coming years, disruptive technological advancements and the increasing development of digital mobility tools is likely to lead to an important paradigm shift in travel. While such a change has great potential to bring benefits for many, it can also exclude those who do not have access to digital tools or find it difficult to use them for various

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reasons. This could lead to greater social inequalities and limit sustainable urban development on different dimensions. Therefore, it is vitally important to understand the needs and capabilities of the end users and to take them into account during the design process of digital products and services.

The main objective of this paper is to explore the potential of creating personas to understand the factors contributing to the digital gap between digital mobility service provision and uptake by different user groups within the digital travel ecosystem.

This contribution is based on work done within the DIGNITY (DIGital traNsport In and for socieTY) project (DIGNITY, n.d.), which explores how to foster a sustainable, integrated, and user-friendly digital travel ecosystem that improves the social inclusion, travel experiences, and daily life of all inhabitants. The study itself is especially focused on Barcelona, one of the 4 pilot cities in the project.

Literature review on the digital divide, inclusive design, transport related disadvantages and mobility poverty conducted within the DIGNITY project (Hoeke et al., 2020) indicated that the majority of previous research done on these matters has focused on each of the topics separately. There was a scarcity of literature addressing the digital divide in mobility in particular.

Therefore, following the DIGNITY approach, the digital divide in mobility sector is here understood as a complex and multidimensional problem that needs to be addressed by applying inclusive design methodologies that put the end user in the centre.

1.1. Digital divide

As defined in OECD (2001), the term ‘digital divide’ refers to the gap between individuals, households, businesses and geographic areas with regard to both their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities. Furthermore, the digital divide reflects differences among and within countries, as well as cities, neighbourhoods, and socioeconomic groups. Therefore, the digital divide is a complex and dynamic phenomenon, reinforcing existing social inequalities.

Van Dijk (2020) describes access to digital technology as a multilevel process which starts with a motivation and positive attitude towards use of the media. Subsequently, one needs physical access to get an appropriate device or/and an Internet connection. The next important factor are the user’s digital skills which allow effective use of the technology. Furthermore, the study author identifies ‘the categories of age, gender, ethnicity, labour, education and nation or region as the most important factors in explaining digital inequality’, because of ‘unequal resources such as material (income), mental (knowledge), social (relationships), and cultural capital’.

Thus, there are many factors affecting the digital divide and it is important to understand how they are spread across the population and how they interact with each other. To address this, a previous survey in the UK examined a range of variables that affect digital exclusion, including technology access and use, attitudes towards technology and digital skills, as well as a variety of socio-demographic variables (Goodman-Deane et al., 2021a). The work described in this paper uses an adapted version of this survey applied to Barcelona context, as described in Section 2.2.

The digital divide is relevant to the mobility sector because inequalities and situations of exclusion can arise from technological and social developments in ICT. Specifically, they are triggered by the emergence of new forms of mobility (e.g. micromobility, new forms of public transport) and the use of ICT to manage and provide an interface to mobility services. Digital exclusion may be caused because the planning and management of transport mobility often fails to take into account the end-users’ needs from a perspective of inclusion and social justice. In fact, some disadvantages are exacerbated by the emergence of new systems and modes of transport that are often managed digitally and thus inaccessible to people with low sovereignty in this area (Wybraniec, 2021).

1.2. Inclusive Design

In this context, a paradoxical situation is being created in which those who could benefit the most from novel mobility solutions are at risk of being left behind due to their lower levels of digital literacy or because solutions are not affordable for them or not accessible (Kuttler & Moraglio, 2020). In large part, these novel solutions are aimed at a general public with high and moderate digital skills and are available in urban areas where there is a wide range of transport services. When it comes to digital technologies, the specific needs of certain demographics are widely missed

out. Consequently, this gap disproportionately affects groups of vulnerable citizens and encompasses various social dimensions. These include users with physical impairments, women, older people, individuals with low income/low education, migrants, and residents of peripheral areas.

Policy makers and mobility service providers have to bear in mind that every design decision on a mobility system has the potential to include or exclude the end-user since every individual is characterised by their diverse capabilities, needs and aspirations. Thus, it is crucial for new mobility solution providers to design the products and services more inclusively.

Inclusive design is a design methodology based on an understanding of users' diversity. It seeks to make mainstream products and services accessible to and inclusive of as many people as possible, by understanding and taking into account the diversity of end-users' needs and characteristics (Cambridge Engineering Design Centre, n.d.). This becomes even more important when individuals face multiple barriers and disadvantages, e.g. those experienced by an older, retired person, with physical disabilities and living in a suburban or rural area. More inclusive solutions can meet a wider range of user needs and make it possible for service providers reach new markets.

Furthermore, although there are multiple inclusive mobility solutions that could benefit vulnerable groups, many of them are available in developed and urbanised areas where the infrastructure needed for the solutions is already in place (Kuttler & Moraglio, 2020). It is important to expand the availability of such solutions to wider parts of society.

1.3. Personas

Personas are fictional profiles based on user research that help designers and other stakeholders to understand and consider the needs of end users during the design process. Personas based on real people experiences and considering their everyday lifestyles enable to grasp and sympathise with the end user interests, values and emotions. Also, using personas can provide important insights for public and policy discussions on specific challenges, highlighting the importance of citizens perspective, emotions and local concerns (Cherry et al., 2022). As a result, they help to overcome biases and physical and cultural distance between the stakeholders, facilitating more contextualised design of solutions (Vestergaard, 2016).

They were introduced to design by Cooper (1999) who used personas to represent the types of users found in qualitative research. Basing personas on qualitative research can produce rich and effective personas. However, qualitative research is typically done with small groups of users and thus there is a danger that it does not capture the whole range of the target user population, particularly when examining diverse user groups (Wöckl et al., 2012). This is particularly relevant to mobility solutions, where the target user group typically includes a wide range of people from across the whole population.

An alternative is to base personas on larger-scale or even population-level survey data using statistical techniques (e.g. Wöckl et al., 2012; Goodman-Deane et al., 2021b). This approach is particularly important in inclusive design, where capturing the diversity across the population is crucial (González de Heredia et al., 2018).

2. Methodology

This section provides description of the methodology applied in order to develop the personas. Firstly, the survey, which provides the data for the study, is introduced. Second, data treatment and cluster analysis carried out in order to obtain the results presented further are explained. Finally, the details on bringing personas to life are described.

2.1. Survey

This work used data from a population-representative survey conducted with 601 residents of the Barcelona Metropolitan Area aged 16 and over in October-November 2020. Using quantitative survey data as the basis for the personas means that they are representative of the whole range of the target population (Wöckl et al., 2012).

The main goal of the survey was to advance the understanding of the digital divide, particularly in the field of mobility, in this region. The questionnaire was adapted from one used in the UK in 2019 (Goodman-Deane et al., 2021a) and covered technology access, technology use (both in general and for transport), limitations in travel,

attitudes towards technology, and measures of digital interface competence (assessed using a simplified paper prototyping method).

The fieldwork of collecting interviews was entrusted to the GESOP (Gabinet d'Estudis Socials i Opinió Pública - Cabinet of Social Studies and Public Opinion), an independent market and opinion research institute from Barcelona. The sample was stratified by district, and municipalities were randomly selected within each stratum. In each municipality, individuals were recruited on-street using quota sampling for age, gender and nationality (Spanish or other). An additional quota was set on level of urbanization in districts outside of Barcelona City. Interviews were conducted on-street face-to-face. This was important because using an online survey would reduce participation from those with low technology access and use, and thus bias the survey. No incentives were offered to participants. Ethical approval for the study was obtained from the University of Cambridge Engineering Department ethics committee.

More detailed information on the survey is available in (Goodman-Deane & Waller, 2022a; Goodman-Deane et al., 2022b) and the dataset will be made available open access on the UPCommons repository (UPCommons, n.d.).

2.2. Cluster Analysis

The survey data was analysed and pre-processed using appropriate statistical methods. This included cleaning data, ordering variables and imputing missing values. Then, a cluster analysis was conducted using six variables, selected from the fields of digitalisation, social exclusion and mobility, with the aim of covering different aspects that encompass those areas. Consequently, the results profess to summarise the participants' responses on various topics related to the digital divide in transport services and its potentially exclusionary effects. The variables were:

- *Technology use*: Frequency of Internet use in any location and on any device in the three months preceding the interview.
- *Basic digital interface competence*: The total number of tests done correctly out of a possible total of eight. Basic technology competence was assessed using simplified paper prototype tests. The interviewees were shown images of smartphone interfaces on paper showcards and were asked to indicate what they would do to achieve a particular goal, such as changing the settings, creating an event on a calendar app or returning to the previous page.
- *Technology confidence*: Confidence to successfully plan an unfamiliar, local public transport journey using the Internet or an app on a smartphone, ranging from low to high levels of confidence.
- *Attitudes towards technology*: The participant's Affinity for Technology Interaction (ATI) score (Franke et al., 2019). This score examines "whether users tend to actively approach interaction with technical systems or, rather, tend to avoid intensive interaction with new systems". It is related to successful coping with technology.
- *Travel limitations*: Limitations in regular travel within the region due to seven different aspects, ranging from not at all limited to very limited. The aspects were grouped using principal component analysis into:
  - Component 1 (Encompassing non-digital aspects of transport limitations): Cost of the travel, limited availability of transport services, limited availability of infrastructure, concerns about safety of the transport services, difficulties using the available transport due to special needs or disabilities.
  - Component 2 (Concerning digital skills required to use transport services): Difficulties because digital skills are needed either while planning travel before a trip or during trips.

Using the selected variables, 7 clusters have been obtained. using a robust version of k-means (k-medoids, Schubert & Rousseeuw, 2019) based on the Gower dissimilarity (Härdle & Simar, 2019).

A persona was then developed for each of the seven clusters, following interpretation and analysis of the clusters' summaries. A similar method was used to that reported in Goodman-Deane et al. (2021b). The values for the clustering variables in each persona were assigned based on the distribution of the values in the cluster and their best fit into the variable categories. Sociodemographic details were chosen and added in order to create a personal description for each cluster.

Each persona was described in terms of its cluster variables in order to emphasize the differences in technology use, attitudes and capabilities. Other personal details and stock photographs were added to bring the personas to life, and to help designers and other stakeholders better understand their lifestyles and daily problems, thus increasing empathy with the personas and the inclusion of their perspectives in decision making. The photographs came from

free access galleries like iStock, Getty Images etc. (iStock, n.d.; GettyImages, n.d.). The names and photographs were selected following the approach presented by the GenderMag Project (Burnett et al., 2016; GenderMag, n.d.), where both male and female photos and details are included in each persona in order to reduce gender stereotyping.

3. Results

A summary of the personas is presented in Figure 1. Each of the variables was banded into three categories with colours assigned from light to dark grey, representing least limited/most digitally literate and most limited/least digitally literate respectively. Likewise, the personas have been ordered from those representing the most digitally excluded individuals to those representing the individuals who are least limited and most familiar with technology.

Persona	Cluster	Cluster size		Frequency of Internet use	Technology Competence	Confidence to plan a trip	ATI score	Limited by travel cost, transport services availability etc.	Limited by digital skills required to plan / during trip
Lu 	1	38	6.4%	Never	Low	Low	Low	Not at all limited	Very limited
Ros 	2	69	11.5%	Sometimes	Low	Low	Low	Not at all limited	Not at all limited
Andre 	3	56	9.4%	Every day	Low	Medium	Medium	Slightly limited	Slightly limited
Adri 	4	90	15.1%	Every day	Medium	High	Low	Slightly limited	Not at all limited
Mar 	5	142	23.7%	Every day	High	High	Medium	Not at all limited	Not at all limited
Vic 	6	95	15.9%	Every day	High	High	High	Slightly limited	Not at all limited
Anto 	7	108	18.1%	Every day	High	High	High	Not at all limited	Not at all limited

Fig. 1. Summary of the distribution of the key variables across the personas set.

Text descriptions were then written for each persona for the categories shown in Figure 1: Use of technology, Competence with technology, Attitudes towards technology (embracing Confidence to plan a trip and ATI Score) and Limitations in regular travel. These descriptions help to extend the summary features and characterise the persona's relationship with technology. In addition, sociodemographic characteristics and other relevant variables from the dataset were chosen, in order to bring their lifestyles and issues to life.

An example of the persona for Cluster 3 is presented in Figure 2. This cluster is the second smallest, containing only 9.4% of the survey participants. Nevertheless, this still represents a sizeable number of people. We decided to focus on this cluster because it highlights that many people use technology on a daily basis, yet still experience problems and limitations related to digital products and services. Examining the people in such a cluster brings their issues into the discussion and points out the necessity of taking their perspectives and requirements into account during the design process.

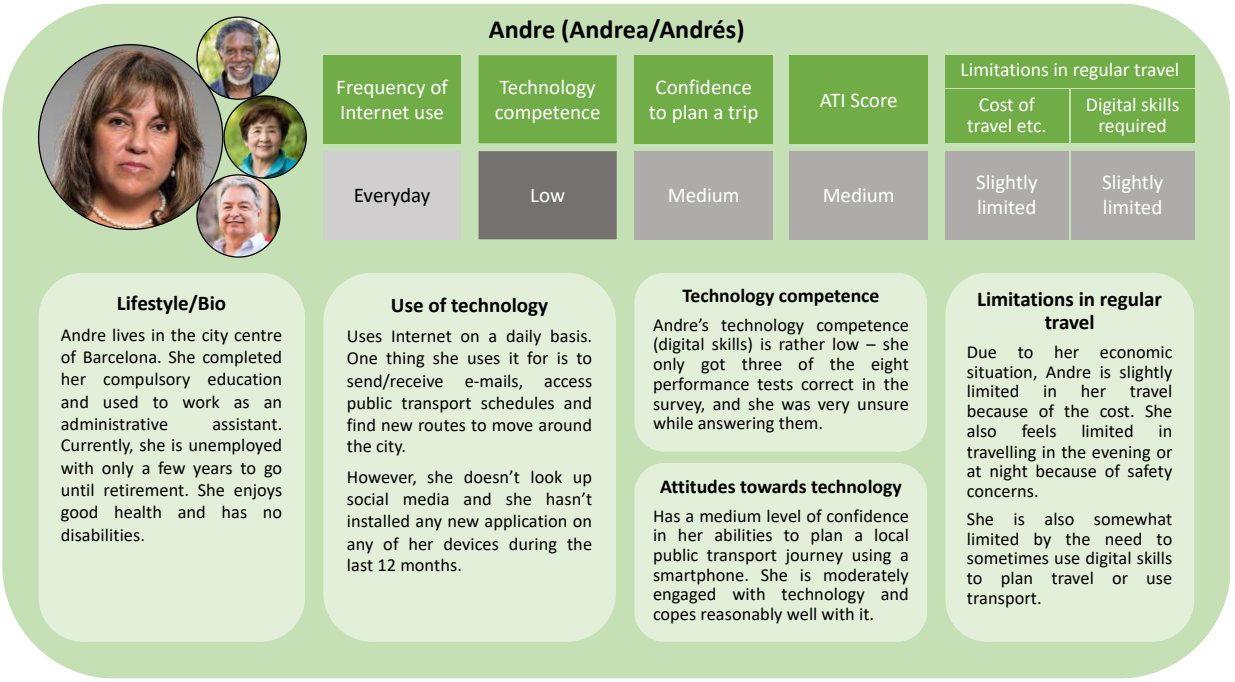

Fig. 2. An example of the persona from the resultant set.

3.1. Discussion

Bare summaries of the clusters do not explain much about the people in the clusters and their problems related to social and/or digital exclusion. They can also be hard for designers to relate to or empathize with. Therefore, it is important to include sociodemographic characteristics and lifestyle descriptions in personas in order to bring them into life and make their problems more tangible. However, focusing demographics could be confusing since there are a range of ages, genders and socio-economic situations within each cluster. Therefore, personas should be focused on the problems and challenges that people face in relation to the clustering variables, rather than on the demographics in order to avoid confusion and stereotypes. Demographics need to be used carefully and reflect the issues described for the persona, bearing in mind real local problems and characteristics of the local mobility ecosystem. This context helps the reader to better understand the limitations, concerns, and habits of the personas and enables them to draw the right conclusions, opening up a space for discussion about possible solutions.

The results show that the majority of population uses Internet on a daily basis (Fig. 1). There are only two clusters representing a lower frequency of use. However, it is important to remember that each cluster actually represents a range of participants. For instance, if the majority of individuals in a cluster uses the Internet daily, there are likely to be some people within this cluster with lower frequency of Internet use. This emphasizes the need to develop new mobility services following the inclusive design principles, making them accessible to as many people as possible.

In addition, the clusters that suffer the most from the digital divide represent rather smaller groups and their problems related to technology and travel are diverse (clusters 1-4). Conversely, the clusters with the least digital exclusion (highest digital literacy and use) are the biggest ones. Moreover, they are more homogenous and their issues do not vary much (clusters 5, 6 and 7). Together they represent roughly 60% of the survey sample, and their issues include only some limitations due to non-digital aspects of transport (e.g. cost of travel, transport services safety).

This suggests that large parts of the Barcelonian population do not have big problems with technology and can take full advantage of novel digital mobility solutions. However, there are still big parts of the population who have serious issues interacting with technology and some of the innovative mobility solutions based on digital interfaces create situations of exclusion for them.

3.2. Limitations

Considering that the personas has been developed using the survey data, the main limitations of the study have to do with the method used for carrying out the interviews, representativeness of the sample and statistical treatment applied.

The survey took place during the COVID-19 pandemic, which may have affected the numbers and make up of people on the street and made some people more cautious about taking part in a face-to-face study. This is likely to disproportionately affect older people and those with underlying health conditions. Both of these groups have lower levels of technology access, use, attitudes and competence and higher levels of travel limitations (Goodman-Deane et al., 2022b). As a result, the survey may underestimate the numbers of people with difficulties with technology and with travel.

Further limitation of the study is the method used for assessing basic technology competence. A paper prototyping method was used instead of tests carried out on real interfaces. It was a trade-off between achieving more interviews and using real tablets within the budget available, since it would be considerably more complicated and expensive to use tablets with this kind of survey size. Thus, this method involved participants imagining what they would do on a real device in order to achieve a particular goal and did not replicate certain gestures, such as swiping or pressing/holding. What is more, it did not allow participants to interact in real time with the device and try out different actions on the interface. This was mitigated by carefully selecting tasks in which success was largely dependent on a single tap of something currently visible on the screen. Furthermore, it is more realistic than the self-report methods commonly used in large scale surveys.

Another limitation is connected to the fast-changing pace of technology which quickly renders such surveys out-of-date. However, the created personas can still help designers to understand the current situation based on the data available.

4. Conclusions and future works

This paper has presented a set of personas based on survey data in the Barcelona Metropolitan Area, focusing on digital exclusion and mobility. The personas could help engineers, designers and policymakers to better understand the diverse needs and capabilities of potential transport service users. This can help them to create digital mobility solutions that fit these needs and capabilities better, resulting in more people being able to use the solutions. In particular, the personas show that there is great diversity in the population with different needs, patterns of technology and transport use, and attitudes towards digital technologies. As the personas are based on a cluster analysis of population-representative survey data, they represent the whole spectrum of people in the target user population. This helps to ensure that key groups are not neglected. Notably, the results show that large parts of the population cannot access digital technologies or lack the knowledge and skills required to use them effectively. As a result, they are not able to take advantage of many digital mobility services. Hence, adaptable solutions, as well as non-digital and low-tech alternatives, are needed to meet different people's requirements and make the mobility ecosystem more inclusive and sustainable.

This work helps to advance the understanding of the factors contributing to the digital gap between digital mobility service provision and uptake by different user groups within the digital travel ecosystem. Getting a solid grasp of these aspects and of the relationships between digitalisation in transport services, digital inequality and mobility poverty is required in order to provide a more inclusive and user-friendly digital travel ecosystem. Measures are needed to make new digital mobility services accessible to the parts of the population experiencing digital exclusion and/or mobility poverty, and to empower vulnerable groups. Without these, new technological solutions will continue to increase the digital gap between sustainable mobility and social inclusion.

Future lines of work include bringing the personas into play and promoting their use for decision making and planning new policies on the local scale. The same survey was conducted in other European countries as part of the DIGNITY project. It could be very insightful to compare the results obtained across the countries. The methodology described in this paper for developing personas could be also applied to other surveys to produce personas tailored for different regions. Future work also includes expanding the personas and elaborating more in-depth stories as well as producing detailed comparisons between different vulnerable-to-exclusion groups within a set of personas.

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