Creating a More Inclusive and Accessible Digital Transport System: Developing the INDIMO Inclusive Service Evaluation Tool

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Abstract. The introduction of smart technologies in mobility has created a vast landscape of possibilities and options, but at the same time they have also created uneven impacts across society. It is, therefore, the goal of this paper to introduce the online Service and Policy Evaluation Tool (SPET) for evaluating the accessibility and inclusivity of digital mobility and delivery services. The tool shall enable policy makers to design strategies necessary for all citizens to fully benefit from the digital mobility system (e.g. social and educational strategies, new regulations, etc.) and identify strategies to avoid digital exclusion in terms of social and spatial aspects. Structurally, the tool is built on the capabilities approach, in combination with the principles of universal design, and co-creation was used for the development of the tool contents. The recommendations from the SPET will assist policy makers, developers, operators and other parties to provide promised benefits of digital services to all sections of the society, especially to people vulnerable to exclusion.

1 Introduction

In order to participate in social or other activities, a person needs to navigate the environment (Vecchio and Martens 2021). The transport environment used to be a purely physical one, but since the introduction of the internet and especially the smartphone, there is an increasing need for digital skills to navigate this new digital transport environment (Vaidian et al. 2019; Velaga et al. 2012). This has, however, proven difficult for many groups in our society, resulting in groups of people that are, more than others, vulnerable to be excluded from participating in social or other activities (Groth 2019; Loos et al. 2020; Pangbourne et al. 2020). Moreover, the proportion of people having access to mobile internet access was still only 74% in 2019, and this form of internet connection is most relevant for using digital services while on the road. The percentage of Europeans who recently (up to 3 months before the Eurostat data collection in 2020) used an internet connection to order online transport service, from an enterprise or private person, is only 9%. For older people, who are often already struggling to fulfil their mobile needs, this is only 4% (Eurostat 2020), indicating the need for improved accessibility and inclusivity of digital transport services.

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Research shows that several characteristics, such as education, income, gender, age, migration background etc. have a significant impact on a person's access to digital transport services (Durand et al. 2022; Estacio et al. 2019; Gorski 2005; van Dijk 2006). These traits are usually combined, e.g. a person with a migration background, who did not receive extensive education, will often earn less and has fewer digital skills, resulting in difficult barriers for her/him to use a digital mobility service (Durand et al. 2022; Sathyan et al. 2022). The lack of access to digital transport solutions is a result of the combination of limiting socio-economic factors and already existing transport disadvantages. Durand et al. (2022) argue that increased exclusion from the digital transport system is already developing within the same groups that currently experience transport disadvantages and a higher degree of social exclusion. The further digitalisation of the transport network is likely to create new lines of transport and social inequality, as well as enforce existing ones. Although some studies have already linked digital exclusion and transport disadvantages, not much empirical research is available yet.

The capabilities approach has been proposed as a possible evaluation approach to appraise the contribution of transport projects and services to wellbeing and freedom to access opportunities (Vecchio and Martens 2021). If we apply the concept of the capabilities approach to digital mobility services, in order to use a service, a person needs to have the ability to utilise mobility resources (e.g. public or private transport). This ability is influenced by knowledge, skills, confidence, physical and mental ability to access and navigate on a digital interface. To increase this ability, it is necessary to provide digital mobility services that require fewer skills and other resources, and which are accessible and inclusive towards people of all abilities.

In this paper, based on definitions by Lucas (2012) and Schwanen et al. (2015), we consider inclusive digital mobility to be a very variable concept, influencing and influenced by any party that is involved, creating a combination of subjective and objective combination of expectations, needs and barriers that need addressing before a digital transport service can be considered to be inclusive. These expectations, needs and barriers can be addressed from different standpoints, given the multitude of stakeholders of the digital transport network. For a definition on accessibility we adopt the definition developed by the European commission which states that accessible digital mobility has to comply with the following two aspects: "Provision of appropriate and sufficient information for the passenger to plan and carry out the journey, and to deal with unexpected disruptions. Provision of the information in the format and via the channel suited to the passenger, especially considering those with visual, hearing, learning and cognitive difficulties" (European Commission et al. 2020, p. 6).

In combination with the capabilities approach, universal design can be a useful concept to create a digital transport system that is accessible and inclusive. The principles of universal design focus on developing a spatial environment that is physically accessible to all (Mace et al. 1998). This means that the environment is developed to fit the skills of all people, including those with a physical disability. When applied to the digital transport system, this results in the development of digital services that need to comply with the needs of people with the lowest digital skills. Creating a digital transport system that answers to those needs requires a co-creative and inclusive approach, with input from those people that are involved in the development process (developers, operators,

policymakers etc.) of digital mobility services and of especially those groups that are currently excluded from these services due to a lack of skills.

In this paper, we introduce the INDIMO Service and Policy Evaluation Tool or SPET, the first tool of its kind that evaluates the inclusivity and accessibility of digital mobility and delivery services. This tool aims to bridge the gap between the abilities of persons vulnerable to exclusion and the requirements of emerging digital mobility and delivery services by providing an online self-assessment tool for evaluating the inclusivity and accessibility characteristics of an existing or new, yet to be introduced service. The tools also provides recommendations on how to improve specific features of an evaluated service so that the accessibility and inclusiveness of the same is improved.

The following research questions need to be addressed for developing a Service and Policy evaluation tool that is efficient and useful.

– How can we facilitate the evaluation of the inclusiveness and accessibility of digital mobility services?

  - Which topics are significant for the development of a digitally inclusive and accessible tool?
  - How are the different key topics included in the tool evaluated and scored?

To answer these questions, we first introduce three key concepts: the capabilities approach, the principles for universal design, which were used as the basis for the tool and the co-creation method which was used to develop and test the tool. Secondly, the conceptual framework is presented, then the methodology of developing the tool is discussed and finally, in the output and structure section, we explain the development of the tool step-by-step, how we evaluated the questions, how the weights were allocated to different topics and how the performance scores are calculated. In the conclusions, we propose additional functions and services that can be included in the SPET, as well as future research on the content and use of the SPET.

2 Literature Review

2.1 Capabilities Approach

Current transport planning and policy are mostly focused on the transport system itself, without actually focusing on those using the system, resulting in the idea that a decent or good working system is enough to provide transport for everyone, indirectly indicating that all people have the possibility to participate in activities (Brown et al. 2009). It cannot be denied that this approach has provided an ever increasing accessibility to a significant part of the population, however, now it is obvious that this does not mean this method has proved to be sufficient for everyone (Lucas 2012). The ever-increasing digitalization of the transport system, and consequentially the increased complexity of the same demands a different approach.

The need for a new approach emerged in the 1990s, with the introduction of the capabilities approach, a theory developed by Amartya Sen and Martha Nussbaum (Nussbaum 2000, 2011; Nussbaum et al. 1993; Sen 1985, 2001, 2009). Various definitions

and descriptions have been adopted, for this paper, we adopt the following definition as proposed by Sen (1995, p.1)" A person's capability to achieve functionings that he or she has reason to value provides a general approach to the evaluation of social arrangements, and this yields a particular way of viewing the assessment of equality and inequality". The capabilities approach was also promoted as a methodology for the appraisal of transport systems, with its foundation in the contribution it provides to a persons' opportunities and wellbeing, which is a basis for consistent evaluative approaches to influence transport planning and policies (Alkire 2003; Vecchio and Martens 2021).

Besides its ability for evaluating transport systems, the capability approach inherently promotes accessible transport systems and thus has a positive impact on the groups in society that are more poorly served by the current transport system than others (Lucas 2012; Martens 2017). Furthermore, it is especially useful when it is used for evaluating a diverse set of people, each with their own capabilities and constraints, keeping in mind the distribution of mobility resources and how these are differently available and used by different people (Vecchio and Martens 2021).

The capabilities approach, especially in relation to mobility has been approached in multiple ways, from a very broad interpretation: 'the ability to be mobile' (Beyazit 2011), from a physical, social and financial point of view, to 'being able to use public transport' (Ryan et al. 2015). Another possible approach was introduced by interpreting accessibility as a capability, rather than just being mobile. This interpretation focused on the participation in society, for which a person needs the be mobile to a degree (Martens 2017).

Lastly, another important difference in interpretation and use of the capabilities approach is combining it with a top-down or bottom-up approach. For the creation of a service or product for people vulnerable to exclusion, the bottom-up approach is preferred as this examines how each person attributes different values to an activity and how this results in participation in activities due to the accessibility provided through the transport system (Vecchio and Martens 2021). In other words, the bottom-up approach includes those people in the development process for whom the product or service is meant. Contrary to the top-down approach, where users are not involved in the development process. A main disadvantage of the top-down approach in this case is the lack of knowledge about barriers and needs that are experienced by people vulnerable to exclusion, as well as other stakeholders of the digital transport network. Therefore, in this paper, we consider the bottom-up approach to be the most suited approach when researching and working with citizens vulnerable to exclusion. In combination with the capabilities approach of Randal et al. (2020), this results in a policy and service evaluation tool that was developed with input from users, developers, operators etc. so that their capabilities, requirements and needs are integrated in the tool.

Universal Design Principles in Digital Service Design

Universal design (UD), a concept first mentioned and used by Ronald Mace, an architect who worked on social inclusion of people with disabilities, is described as "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (Aarhaug 2019, p. 2). This resulted in a first, comprehensive approach to develop a more inclusive world. Earlier attempts resulted in a segregated approach, one infrastructure for those without 'disabilities' and

one for those who needed an adapted approach. These attempts usually were considered to be ugly and required additional investment (Mace et al. 1998). Throughout the years, the way UD was approached has evolved and a vision emerged that UD promotes a new approach to design that celebrates diversity and provides equal opportunity of access to mobility and services (Audirac 2008). In the EU, as part of the General accessibility act (2019), the concept of UD is defined and integrated within the legislation for the development of products and services (European Commission 2019). A more recent practical evolution is the implementation of UD in digital services, with Begnum and Bue (2018) concluding that there is still a significant lack of awareness of UD among designers and other stakeholders.

The widespread emergence of services, especially digital services, has resulted in the fast growth of service design, focusing on the holistic experience of users, with the goal to make services user friendly, easy to use and more intuitive (Polaine et al. 2013; Scott et al. 2016). According to Begnum and Bue (2021) a widely accepted definition of an inclusive digital service is still not available, so, in this paper, we adopt the working definition as described in their work: "A service is universally designed when its customer journey is usable to all people (to the greatest extent possible and without the need for adaptation or specialized design), by selecting suitable touchpoints" (Begnum and Bue 2021, p. 22). The design has a significant impact on the value creation of the digital services (Law et al. 2008) and consequently on society as well (Kuk and Janssen 2013), with digitalized services dominating society at an ever increasing pace (Newman 2020). The impact service design has, is significant, and even though there is an idea on the relevant concepts linked to universal service design, awareness about this method is overall lacking (Begnum and Bue 2021; Delaere et al. 2020).

The introduction of universal design, or inclusive design, which are often used as synonyms (Goodman-Deane et al. 2010; Clarkson and Coleman 2015) in digital services has resulted in the development and design of more inclusive digital services. Adopting universal design principles when developing services is not necessary for most users, but it does provide the opportunity for vulnerable to exclusion people to make use of the services as well, resulting in a more accessible and inclusive service for all users. In this regard, one set of regulations that has proven impactful are the Web Content Accessibility Guidelines, which are guidelines defining how to make Web content more accessible to people with disabilities. Accessibility involves a wide range of disabilities, including visual, auditory, physical, speech, cognitive, language, learning, and neurological disabilities (W3C 2008). Within the European digital landscape, the Web Content Accessibility Guidelines 2.0 (WCAG 2.0) are mandatory for National agencies, and their contractors (European Union Agency for Fundamental Rights 2014). Additional guidelines are available in the WCAG 3.0, which have significant overlap with WCAG 2.0, but it introduces an alternative to previous versions (W3C 2021). Although WCAG has resulted in an increase of the accessible character of web based applications and platforms, since social and spatial inclusion is not really integrated into the definition of the WCAG, it does not provide an answer or guideline to all barriers of digital services (Begnum et al. 2018). Tools have been developed to assess the inclusive character of projects, programs, organisations and companies, but only a few have been created

for the evaluation of digital services (Department for Digital, Culture, Media and Sport 2017), with none focusing on digital mobility services.

The implementation of UD principles in legislation shows an effort for a more generally accessible design and use of services and products. Nevertheless, there is still a lack of knowledge among developers, designers regarding UD in service design. Moreover, inclusivity of services and products is often only a sidenote in the company goals or not mentioned at all (Delaere et al. 2020). This is where the SPET can fill an existing gap, it can provide assistance to evaluate the digital inclusivity of digital mobility services and can provide guidelines to design, develop and implement accessible, inclusive digital mobility services.

2.2 Co-creation as an Approach to Develop Tools

Pappers et al. (2020) stated that the use of co-creation, as a form of public participation has become more present in multiple industries, especially within health and education. In transport development and policy, co-creation has only recently become more of a standard, advocated by the European commission with projects like those within HORIZON2020.

Developing digital mobility services that are accessible and inclusive require user-centred development, and applies a bottom-up approach, meaning that the users are involved in the development process and have a significant impact on the final output. One way of involving users in the design of a service is using 'co-creation', that can be interpreted as a more intense, further reaching form of customization, involving "collaboration with customers for the purpose of innovation" (Kristensson et al. 2008, p. 47). In a co-creation process the focus shifts from the firm or company to the users, who are significantly involved in the development process addressing user- specific needs (Chathoth et al. 2013).

The first stakeholder group, mainly the users, are mostly the sole focus of inclusivity measures, as these are the people that might potentially be excluded. But, for the development of a digital service, it is not sufficient only to keep in mind the users, as this can result in demands that cannot be fulfilled by developers, operators or policy makers. Therefore, it is important that both sides have sufficient input in the development of the tool. This will eventually result in a service that is inclusive and accessible for all users, but will also make sure that all inclusion related changes and measures are feasible for the developers, operators and policy makers to implement as well.

Conceptual Framework

The Service and Policy Evaluation Tool, that we developed, addresses the gap between the provided capabilities of potential users, and the required capabilities of a digital mobility or delivery service based on the capabilities model of Randal et al.(2020). It is intended to align the set of requirements posed by a digital service to match the capabilities of potential users to facilitate their participation in society. The tool aims to help the key stakeholders that have an influence on the development of digital applications and services, i.e. developers, operators and policy makers, to make digital mobility services universally accessible and inclusive.

The goal of the SPET is to intervene in matching both sides of the capabilities model (Fig. 1). Provided capabilities (e.g. digital skills), have to match the required capabilities (constraints) in order for a person to participate in a specific activity (e.g. visiting a family member), which are influenced by the actual activity (e.g. using a ride-sharing service) and the environment, i.e. digital and physical context in which the activity will take place (e.g. the smartphone application that is needed to book a ridesharing service as well as being able to find a physical meeting point to get to the vehicle)(Vecchio and Martens 2021). Applying universal design to the service and the environment could help to design a service that accommodates the capabilities of as many people as possible rather than designing specialised services addressing capability limitations. In order to facilitate universal design, developers need to take it into account when designing the service and its interface; operators need to consider it when they operate a digital mobility service; and policy makers need to create guidelines and regulations that incentivise developers and operators to comply with accessibility and inclusivity requirements. If the Universal Design principles are considered, the activity and the environment can be designed in a way that accommodates the requirements of the users in a broad sense and the capability gap disappears or it is at least decreased. In this way, a user would be able to book a ridesharing service through a smartphone app, communicate with the driver and find the meeting point and board the vehicle in order to reach her/his destination irrespective of her/his level of digital skills.

The SPET has both an assessment and a steering role in this process. On the one hand, it would allow policy makers, as well as developers and operators to assess to what extent a service complies with minimum and recommended accessibility and inclusiveness standards; but on the other hand, it would also steer service design by giving recommendations on applying universal design to improve specific features of services and applications.

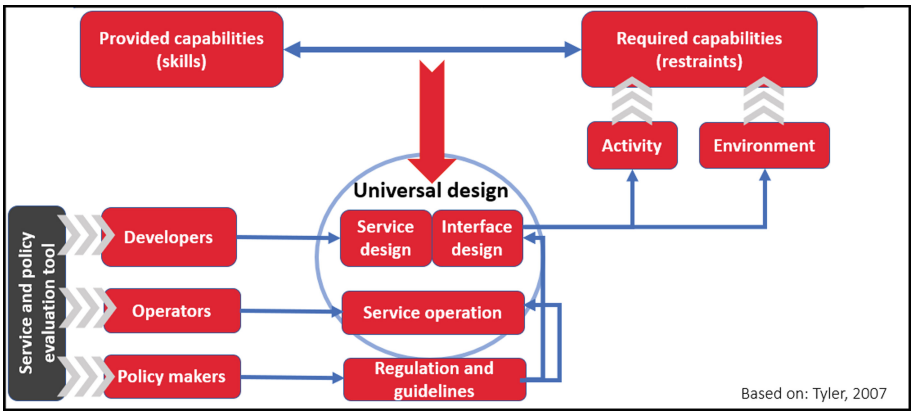

Fig. 1. Conceptual framework of SPET

3 Methodology of the Development of the SPET

The SPET was developed through a co-creation process involving the two main stakeholder groups: the citizens, i.e. the users and non-users of digital mobility services and the stakeholders that are involved in the development, implementation and operation of the digital mobility services (developers, operators and policy makers). The creation of the SPET was a multi-step process, presented in Fig. 2.

In the first step of the development the requirements of the stakeholders towards the tool were identified. We carried out 10 case studies of digital mobility and delivery services to assess how accessibility and inclusion were considered in their development. As part of the case studies, 18 interviews with operators, developers and policy makers provided information about the drivers and barriers they experience during the development, implementation and operation of an inclusive digital mobility service (Delaere et al. 2020). Then a co-creation workshop was organised where 36 experts discussed and elaborated on the drivers and barriers that were collected from the interviews. This provided us with a more extensive understanding of the barriers, as well as the differences between different kinds of stakeholders.

In the second step, we defined the set of capabilities of users and non-users (skills) and the requirements of digital mobility and delivery services (constraints) through a comprehensive qualitative research process. 70 interviews were conducted with users and non-users of the digital transport system with a focus on the people vulnerable to exclusion. Additionally, 25 interviews were conducted with stakeholders representing people vulnerable to exclusion as part of 10 user case studies. In these interviews we investigated the required capabilities to use a digital mobility service and the provided capabilities by people vulnerable to exclusion (Ciommo et al. 2020a, b; Vanobberghen et al. 2020).

In the next step, guidelines were developed for applying universal design in the development of digital mobility and delivery services and applications. The first set of guidelines were collected in the Universal Design Manual – (UDM)(Ciommo et al. 2020a, b); secondly, there are the guidelines for universal language interface icons and accessible interfaces (UIL)(Hueting et al. 2020), and the last set of guidelines are those about cybersecurity, privacy assessment and data protection (CSG) (Capaccioli et al. 2020). These documents provided the set of minimum requirements and recommendations to be used in the SPET. These are represented as a set of themes and topics (see in the next section), as well as the questions that are included in the SPET.

A co-creation workshop with 28 mobility experts was organised during which the topics and questions were reviewed, discussed and changes were suggested. To finalize the development of the questions, the same process was repeated a second time with 19 developers, operators and researchers.

In the fourth step, weights and scores were developed for the questions in the SPET since during the co-creation workshops, it became clear that the mobility and inclusivity experts did not consider each topic to be equally important. Thus, a weighting exercise was organised to find out which topics they considered to be relatively more important compared to others.

In the fifth step, an online web version to facilitate the accessibility and inclusivity assessment, was developed, tested and evaluated.

In June 2022, a first test for the SPET was organised with 24 experts comprising of researchers, developers and policy makers from cities across Europe. During this test the participants used the SPET to evaluate several digital mobility and delivery services: Cambio[1] (carsharing), Bpost[2] (eletronic parcel locker), Uber Eats[3] (food delivery), BlaBlaCar[4] (ridesharing) and Citymapper[5] (multimodal routeplanner). While completing the evaluation of one of these services the participants answered a survey about the clarity and understandability of the questions, answers, definitions and results in the SPET.

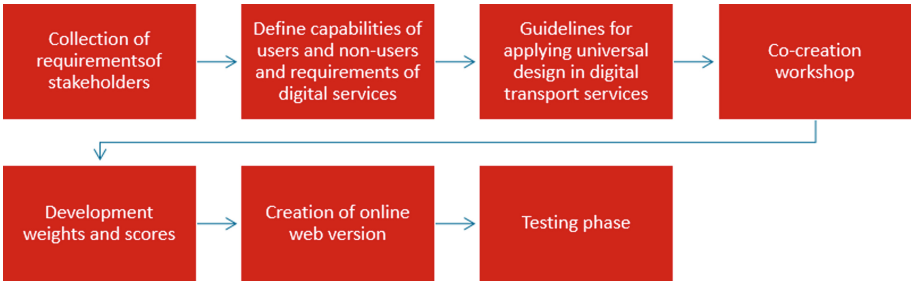

Fig. 2. Stepwise creation process of SPET

4 Structure and Output of SPET

This section has the following structure: first the different types of evaluations are explained, focusing on the type of service and the evaluator, secondly the themes, topics and related questions are defined, thirdly we talk about the structure of the questions, a fourth section focuses on the weighting of the topics, followed by an explanation on how the scoring takes place and finally how the output of the tool is produced.

4.1 Types of Evaluation in the SPET

Before evaluating the digital inclusivity and accessibility of a mobility service, the evaluator will have to select what kind of service will be evaluated and which type of stakeholder (developer, designer, operator or policy maker) she or he is. Based on these choices, a specific set of topics and questions is presented to the evaluator.

[1] www.cambio.be.
[2] www.bpost.be.
[3] www.ubereats.com.
[4] www.nl.blablacar.be.
[5] www.citymapper.com.

The services currently available for evaluation are those linked to the INDIMO pilot projects (food delivery, ride- and car-sharing, electronic parcel lockers and multimodal route planners), with 'other' as an additional option, to provide the evaluator with the option to evaluate another type of service.

Once this information has been entered in the tool, the actual evaluation starts, in which the evaluator will have to provide answers to the questions linked to each of the evaluation-topics (Table 1). The structure of the questionnaire is threefold, linked to the three themes present within the tool: Universal Design Principles, service features and assistance provided.

4.2 Topics and Questions for Evaluation

As explained in previous sections, input for the tool is based on multiple interviews with each of the stakeholder groups, after which the information was used to develop the UDM, UIL and SCG.

To create a clear structure three themes, based on the collected information, were created, the first theme is the universal design principles, which is based on an adaptation of the standard universal design principles. From the original seven principles, five were kept, the other principles (simple and intuitive, size and space for approach and use) were left out. In the digital world, 'simple and intuitive' was considered to be very different for each stakeholder group and service, also, for a large part, this aspect is covered by the other principles. The 'size and space for approach and use' was not necessary as the physical aspect is not evaluated by the SPET, rather this principle was replaced by digital (and spatial) wayfinding. The last topic that was included in this theme, is the data protection and privacy of the users. Furthermore, one principle was adapted slightly, a cognitive part was added to the low physical effort principle, to better fit with the digital approach.

The second theme 'service features' is an umbrella term for all the topics related to the inclusivity of the services considering pricing, payment methods, information provision, communication and spatial accessibility.

Finally, the third theme 'assistance offered' refers to the topics that provide help for those who have issues using the application or the service, as well as focusing on the iconology used in the application. This topic was identified as a separate topic as one of the key findings of the interviews with users and non-users was that people would need human assistance when using digital mobility services.

This resulted in 18 topics, divided among three main themes as presented in Table 1.

Table 1. Evaluation topics included in the service and policy evaluation tool

Theme	Number of questions	Explanation
Universal Design Principles	34	
Flexibility	6	The design accommodates a wide range of individual preferences and abilities
Equitability	7	The design is useful and marketable to people with diverse abilities
Perceptibility	3	The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities
Tolerance for error	2	The design minimizes hazards and the adverse consequences of accidental or unintended actions
Physical and cognitive effort	1	The design can be used efficiently and comfortably and with a minimum of fatigue
Digital and spatial wayfinding	6	How easily can someone navigate the app and the spatial environment to use the service
Data protection and privacy	9	How privacy and GDPR are taken into account and presented to the user
Service features	27	
Payment	8	The different options for users to pay for their ride, order, trip, subscription, etc
Subscription, reservation & registration	4	The subscription, reservations and registrations options that are available, as well as their usability
Price and affordability	5	The different options of tickets and subscriptions that are available so all people, no matter their financial status can make use of the service
Information	4	The availability and accessibility of information about the service and application
Communication	4	What channels are used for communicating about the service and how effectively info is communicated

(*continued*)

Table 1. (*continued*)

Theme	Number of questions	Explanation
Service area	2	The operational area of a service (geographical and across socio-demographic groups)
Assistance provided	13	
Digital capability	2	The skills needed to access digital tools & use them according to individual needs
Audio assistance	2	Auditory assistance provided within the application to help people (e.g. by telephone)
Autism	2	Specific features of an application to make use easier for people with autism
User feedback	5	How users can provide feedback, how fast operators respond and to what changes feedback lead
Iconology	3	Use of icons has a significant impact on usability, perceptibility,…

Each of these themes, with their appropriate topics form the core structure of the tool. For the evaluation of individual topics, a number of questions were developed for each theme.

4.3 Structure of the Questions

The entire questionnaire is made up of three types of questions, categorized by the way in which they are answered. The first type of questions requires a 'yes or no' answer, the second type are answered in a Likert scale with 3 or 5 potential answers, the last type of questions are the ones that can be answered by selecting suitable option from multiple choices. Once the evaluator has answered all questions the topic and theme-wise scores are calculated.

However, the final score does not only depend on the answers from the evaluator, but it is also influenced by the weights allocated to each of the topics.

4.4 Weighting of the Topics

Each of the topics was described and presented to, and discussed by, 29 experts in the field of digital mobility, policy and inclusivity in order to determine the relative importance of the topics. Experts concluded that all three themes are equally important for an accessible and inclusive application or service, but topics under a certain theme may differ in their relative importance. For allocating weights to each of the topics, a survey was distributed among the experts (operators, developers, researchers and mobility professionals) participating in the INDIMO project. To quantify the relative importance of the topics, the experts were asked the question: 'Relative to the importance of other topics in this theme, how would you score this topic out of 20'. It was decided to use a scale of 1–20 with the consideration and objective of providing experts a scale wide enough to comfortably express the differences in the perceived importance of each topic. Based on the scores provided by experts, the topics within a theme were compared and weights, relative to each other, were allocated to the topics Table 2. The standard deviation of the weights allocated to each topic is also included in Table 2, showing the variance in answers provided by the experts.

Table 2. Allocation of weights to each of the SPET topics

Theme	Topic	Theme weights	Topic weight score on 20	Std Dev	Topic weight
Universal Design Principles	Flexibility	0.33	15	2.95	0.0457
	Equitability		15.64	3.46	0.0476
	Perceptibility		17.5	2.23	0.0533
	Tolerance for error		14.93	2.91	0.0455
	Physical and cognitive effort		15.21	3.38	0.0463
	Digital (and spatial) wayfinding		15.71	2.79	0.0479
	Data protection and privacy		15.43	4.27	0.0470
	Total/Average		**15.63**	3.14	**0.33**
Service features	Payment	0.33	14.43	2.64	0.0540
	Subscription, reservation & registration		13.57	3.54	0.0508
	Price and affordability		15.36	3.04	0.0575

(*continued*)

Table 2. (*continued*)

Theme	Topic	Theme weights	Topic weight score on 20	Std Dev	Topic weight
	Information		16.64	2.58	0.0623
	Communication		14.86	3.4	0.0557
	Service area		14.14	3.83	0.0530
	Total/Average		**14.83**	3.17	**0.33**
Assistance offered	Digital capability	0.33	16.07	3.73	0.0660
	Audio assistance		16.64	3.99	0.0684
	Autism		15.86	3.7	0.0652
	User feedback		16.5	2.87	0.0678
	Iconology		16.07	3.73	0.0660
	Total/Average		**16.45**	**3.50**	**0.33**

Calculating the weights for each topic happens as follows: for the simplicity of calculation and convenience of understanding and presentation, total weight for all themes is considered to be 1. After this the total weight was equally distributed among three themes which are equally important from the perspective of accessibility and inclusivity of an application and service. This way, the weight allocated to each theme is 0.33 (approximately). Then 0.33 was divided among topics according to the ratio of the average score (out of 20), allocated by the experts to each topic to find the topic weights. The actual weight is then calculated by dividing the topic weight score by the sum of all topic weight scores within a theme. The result of this calculation is presented in Table 2 in the column on the right 'Topic weight'.

4.5 Assessment Results and Recommendations

The final score for each theme is calculated based on the answers for each of the questions that topic contains. Table 2 shows the number of questions for each topic, the number of questions does not have an effect on the importance of a theme. Due to the fact that yes/no questions, multiple choice and different Likert scales are used, a transformation is necessary (Table 3). Each of the scores is re-distributed on a 20 point scale. After the re-distribution, the average of all the unweighted score for each question results in the unweighted topic score.

Table 3. Re-distribution answers SPET.

Original answer	Re-distributed answer
Yes – no	20, 0
3 point Likert scale	0, 10, 20
5 point Likert scale	0, 5, 10, 15, 20
Multiple choice	Equal distribution on 0–20 scale (depending on the question: the more/the less, the better)

Once the evaluation of the service is finished, i.e. the evaluator answered all the questions, the average of all weighted topics scores results in the theme performance score. Finally, the average of the three themes results in the overall performance score for the evaluated digital transport service. An example is given in Table 4.

Table 4. Example calculating theme performance score

Topic	Weight score on 20	Topic weight	Score (based on input policy maker) on 20	Weighted performance score on 20	Theme average %
Flexibility	15	0.04524	16	14.48	64.76
Equitability	15.64	0.04717	18	16.98	
Perceptibility	17.5	0.05278	14	14.78	
Tolerance for error	14.93	0.04503	12	10.81	
Physical and cognitive effort	15.21	0.04587	12	11.01	
Digital (and spatial) wayfinding	15.71	0.04738	16	15.16	
Data protection and privacy	15.43	0.04654	8	7.45	

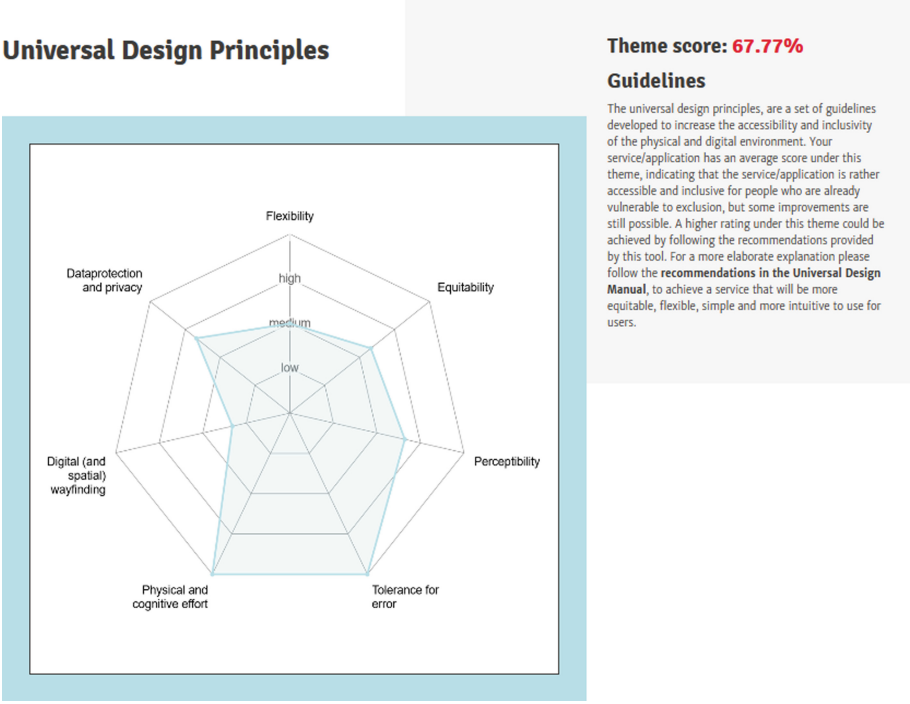

Fig. 3. Example for result spider diagram

After this step all calculations are finished and the results are presented. For each theme a spider diagram is shown (Fig. 3), containing each of the topics included and their performance score in percentage giving the evaluator an easy-to-interpret result. Besides the spider diagram, the evaluator receives the performance scores for each of the three themes, accompanied by a general recommendation, as well as an overall performance score. Three general recommendations are possible, depending on the score of the theme (low, medium or high).

If the evaluator wants a more detailed representation of the results, this is possible as well. For each of the evaluated topics the evaluator receives a score and recommendations that would help to improve the service so that the performance score for a specific topic increases, this of course with the ultimate goal to improve the digital inclusivity and accessibility of the mobility service.

The recommendations are the final result produced by the SPET, providing the evaluator with relevant information on how to make the service more digitally inclusive and accessible. Each of the recommendations (Fig. 4) are specifically linked to the questions in the tool, providing detailed and focused interventions to the evaluator. Depending on the score for each topic different recommendations are presented in three categories: low, med, high, depending on their importance for a more inclusive service.

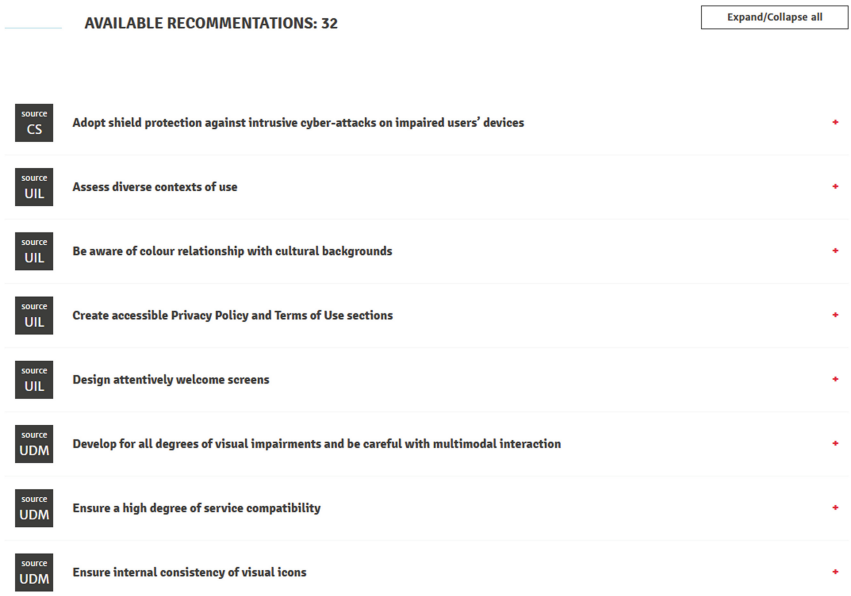

Fig. 4. Recommendations output from the SPET

Recommendations included in the tool are all linked to the aforementioned INDIMO toolbox providing a more elaborate explanation about every recommendation. The recommendations are all organised in the INDIMO toolbox and explained in these documents: (Capaccioli et al. 2020; Ciommo et al. 2020a, b; Hueting et al. 2020).

5 Conclusion and Next Steps

This Service and Policy Evaluation Tool or SPET is the first attempt to develop a tool that provides the opportunity to evaluate the inclusivity and accessibility of a digital mobility service to multiple stakeholder groups. The tool that can be used to evaluate services on multiple topics related to inclusion and accessibility, and we developed a method to quantify these topics. Both the topics and calculating the inclusivity and accessibility score of the services, as well as the recommendations, will provide policy makers and other stakeholders with the framework to efficiently evaluate and score digital mobility services, resulting in the selection of more inclusive and accessible digital mobility services that are allowed to operate.

At the time of writing this paper, the tool was still in its development phase, so no actual testing of the tool has been carried out. The future steps in the development of the SPET are the testing and validation by policy makers and other stakeholders of which the next phase takes places in September 2022. The input from these events will be used for further development of the tool.

A second change that can prove useful is the possibility to adapt the weights distributed between the different topics within a certain range. This way based on the

context the evaluator could, to some extent, decide which topics he or she considers more important and thus give a higher weight to that topic. A proposal to do so would be to provide a range, based on the standard deviation from the weighting survey, along which the weight can be changed.

Also, currently, it is only possible to evaluate an entire service, rather than one aspect (application, interfaces and service). In future phases the option will be provided to the evaluator to choose one or more aspect of the service, for which the main motivation is a simpler and faster evaluation for the evaluator.

The most important development that can still be implemented in the tool is the integration of additional services for evaluation. Currently, only the types of services researched in the HORIZON2020 project INDIMO are included, which limits the use of the tool. For future versions, it would be preferable to include other services such as multiple micro-mobility services. At the same time, the SPET can also be adapted to evaluate the services that are not digital, either in the domain of mobility or not. These changes would have a positive effect on the applicability and usability of the tool and should be considered for future research, as well as intensive testing with different services, stakeholders and in a wide variety of cities and regions.

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References

Aarhaug, J.: Universal design as a way of thinking about mobility. In: Müller, B., Meyer, G. (eds.) Towards User-Centric Transport in Europe. Lecture Notes in Mobility, pp. 75–86. Springer, Cham (2019). https://doi.org/10.1007/978-3-319-99756-8_6

Alkire, S.: The capability approach as a development paradigm? In: Conference on the Capability Approach, Pavia (2003)

Audirac, I.: Accessing transit as universal design. J. Plan. Lit. **23**(1), 4–16 (2008). https://doi.org/10.1177/0885412208318558

Begnum, M., Bue, L.O., Eileen, M.: Towards inclusive service design in the digital society: current practices and future recommendations. In: DS 91: Proceedings of NordDesign 2018, Linköping, Sweden, 14th–17th August 2018. NordDesign 2018. (2018). https://www.designsociety.org/publication/40964/Towards+Inclusive+Service+Design+in+the+Digital+Society%3A+Current+Practices+and+Future+Recommendations

Begnum, M.E.N., Bue, O.L.: Advancing inclusive service design: defining, evaluating and creating universally designed services. In: Rauterberg, M. (ed.) Culture and Computing. Design Thinking and Cultural Computing. Lecture Notes in Computer Science, vol. 12795, pp. 17–35. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-77431-8_2

Beyazit, E.: Evaluating social justice in transport: lessons to be learned from the capability approach. Transp. Rev. **31**(1), 117–134 (2011). https://doi.org/10.1080/01441647.2010.504900

Brown, J.R., Morris, E.A., Taylor, B.D.: Planning for cars in cities: planners, engineers, and freeways in the 20th century. J. Am. Plann. Assoc. **75**(2), 161–177 (2009). https://doi.org/10.1080/01944360802640016

Capaccioli, A., Giorgi, S., Hueting, R., Rondinella, G., Ciommo, F.D.: D2.6 – Guidelines for cybersecurity and personal data protection (public version). Data Protection, 66 (2020)
Chathoth, P., Altinay, L., Harrington, R.J., Okumus, F., Chan, E.S.W.: Co-production versus co-creation: s process based continuum in the hotel service context. Int. J. Hosp. Manag. **32**, 11–20 (2013). https://doi.org/10.1016/j.ijhm.2012.03.009
Ciommo, F.D., Kilstein, A., Rondinella, G.: D2.1 – Universal Design Manual – Version, p. 178 (2020a)
Ciommo, F.D., Rondinella, G., Kilstein, A.: D1.3—Users capabilities and requirements, p. 310 (2020b)
Delaere, H., Basu, S., & Keserü, I. (2020). D1.4 – Barriers to the design, planning, deployment and operation of accessible and inclusive digital personalised mobility and logistics services. 96
Department for Digital, Culture, Media & Sport. Digital Inclusion Evaluation Toolkit. GOV.UK (2017). https://www.gov.uk/government/publications/digital-inclusion-evaluation-toolkit
Durand, A., Zijlstra, T., van Oort, N., Hoogendoorn-Lanser, S., Hoogendoorn, S.: Access denied? Digital inequality in transport services. Transp. Rev. **42**(1), 32–57 (2022). https://doi.org/10.1080/01441647.2021.1923584
Estacio, E.V., Whittle, R., Protheroe, J.: The digital divide: examining socio-demographic factors associated with health literacy, access and use of internet to seek health information. J. Health Psychol. **24**(12), 1668–1675 (2019). https://doi.org/10.1177/1359105317695429
European Commission. Directive (EU) 2019/ of the European Parliament and of the Council of 17 April 2019 on the accessibility requirements for products and services, p. 46 (2019)
European Commission. Directorate General for Mobility and Transport., TIS., Panteia., ITS Leeds., & Armis. (2020). Improving accessibility of persons with reduced mobility by improving digital travel information services: A selection of good practices in Europe. Publications Office. https://data.europa.eu/doi/10.2832/836345
European union agency for fundamental rights. are there legal accessibility standards in place for websites providing public information? European union agency for fundamental rights (2014). https://fra.europa.eu/en/content/are-there-legal-accessibility-standards-place-websites-providing-public-information
Eurostat. Eurostat—Tables, Graphs and Maps Interface (TGM) table (2020). https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tin00083&language=en
Goodman-Deane, J., Langdon, P., Clarkson, J.: Key influences on the user-centred design process. J. Eng. Des. **21**(2–3), 345–373 (2010). https://doi.org/10.1080/09544820903364912
Gorski, P.: Education equity and the digital divide. AACE J. **13**(1), 43 (2005)
Groth, S.: Multimodal divide: reproduction of transport poverty in smart mobility trends. Transp. Res. Part A: Policy Pract. **125**, 56–71 (2019). https://doi.org/10.1016/j.tra.2019.04.018
Hueting, R., Giorgi, S., Capaccioli, A., Bánfi, M., Soltész, T.D.: D2.3 – Universal Interface Language – Version, p. 212 (2020)
John Clarkson, P., Coleman, R.: History of inclusive design in the UK. Appl. Ergon. **46**, 235–247 (2015). https://doi.org/10.1016/j.apergo.2013.03.002
Kedmi-Shahar, E., Delaere, H., Vanobberghen, W., Di Ciommo, F.: D1.1 –AnalysisFramework of User Needs, Capabilities, Limitations & Constraints of Digital Mobility Services Deliverable D1.1; INDIMO, Nummer D1.1, p. 103 (2020)
Kristensson, P., Matthing, J., Johansson, N.: Key strategies for the successful involvement of customers in the co-creation of new technology-based services. Int. J. Serv. Ind. Manag. **19**, 474–491 (2008). https://doi.org/10.1108/09564230810891914
Kuk, G., Janssen, M.: Assembling infrastructures and business models for service design and innovation. Inf. Syst. J. **23**(5), 445–469 (2013). https://doi.org/10.1111/j.1365-2575.2012.00418.x

Law, C.M., Yi, J.S., Choi, Y.S., Jacko, J.A.: A systematic examination of universal design resources: part 1, heuristic evaluation. Univ. Access Inf. Soc. **7**(1), 31–54 (2008). https://doi.org/10.1007/s10209-007-0100-1

Loos, E., Sourbati, M., Behrendt, F.: The role of mobility digital ecosystems for age-friendly urban public transport: a narrative literature review. Int. J. Environ. Res. Public Health **17**(20), 16 (2020). https://doi.org/10.3390/ijerph17207465

Lucas, K.: Transport and social exclusion: where are we now? Transp. Policy **20**, 105–113 (2012). https://doi.org/10.1016/j.tranpol.2012.01.013

Mace, R.L., Mueller, J.L., Story, M.F.: The universal design file, p. 172 (1998)

Martens, K.: Transport justice: designing fair transportation systems. Routledge, Taylor & Francis Group (2017)

Newman, D.; Top 10 Digital Transformation Trends For 2021. Forbes (2020). https://www.forbes.com/sites/danielnewman/2020/09/21/top-10-digital-transformation-trends-for-2021/

Nussbaum, M.C.: Women and Human Development the Capabilities Approach. Cambridge University Press (2000)

Nussbaum, M.C.: Creating capabilities the human development approach. Orient Blackswan (2011)

Nussbaum, M.C., Sen, A.: World Institute for Development Economics Research (Red.). The Quality of life. Clarendon Press ; Oxford University Press (1993)

Pangbourne, K., Mladenović, M.N., Stead, D., Milakis, D.: Questioning mobility as a service: unanticipated implications for society and governance. Transp. Res. Part A Policy and Pract. **131**, 35–49 (2020). https://doi.org/10.1016/j.tra.2019.09.033

Pappers, J., Keserü, I., Macharis, C.: Co-creation or public participation 2.0? An assessment of co-creation in transport and mobility research. In: Müller, B., Meyer, G. (eds.) Towards User-Centric Transport in Europe 2. Lecture Notes in Mobility, pp. 3–15. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-38028-1_1

Polaine, A., Lovlie, L., Reason, B.: Service design from insight to implementation. Rosenfeld Media (2013). https://public.ebookcentral.proquest.com/choice/publicfullrecord.aspx?p=5198114

Raghavan Sathyan, A., et al.: Digital competence of higher education learners in the context of COVID-19 triggered online learning. Soc. Sci. Humanit. Open **6**, 100320 (2022). https://doi.org/10.1016/j.ssaho.2022.100320

Randal, E., et al.: Fairness in transport policy: a new approach to applying distributive justice theories. Sustainability **12**(23), 10102 (2020). https://doi.org/10.3390/su122310102

Ryan, J., Wretstrand, A., Schmidt, S.M.: Exploring public transport as an element of older persons' mobility: a capability approach perspective. J. Transp. Geogr. **48**, 105–114 (2015). https://doi.org/10.1016/j.jtrangeo.2015.08.016

Schwanen, T., Lucas, K., Akyelken, N., Cisternas Solsona, D., Carrasco, J.-A., Neutens, T.: Rethinking the links between social exclusion and transport disadvantage through the lens of social capital. Transp. Res. Part A Policy Pract. **74**, 123–135 (2015). https://doi.org/10.1016/j.tra.2015.02.012

Scott, M., DeLone, W., Golden, W.: Measuring eGovernment success: a public value approach. Eur. J. Inf. Syst. **25**(3), 187–208 (2016). https://doi.org/10.1057/ejis.2015.11

Sen, A.: Well-Being, agency and freedom: the Dewey lectures 1984. J. Philos. **82**(4), 169 (1985). https://doi.org/10.2307/2026184

Sen, A.: Functionings and Capability. In: Sen, A., Inequality Reexamined 1ste dr, pp. 39–55. Oxford University Press, Oxford (1995) https://doi.org/10.1093/0198289286.003.0004

Sen, A.: Development as Freedom 1 edn. 6th print. Alfred A. Knopf, p. 366 (2001)

Sen, A.: The idea of justice 1. Harvard University Press paperback ed. Belknap Press of Harvard University Press, p. 467 (2009)

Vaidian, I., Azmat, M., Kummer, S.: Impact of Internet of Things on Urban Mobility -, Red, pp. 4–17. HBMSU (2019). https://epub.wu.ac.at/7101/

van Dijk, J.A.G.M.: Digital divide research, achievements and shortcomings. Poetics **34**(4–5), 221–235 (2006). https://doi.org/10.1016/j.poetic.2006.05.004

Vanobberghen, W., et al.: D1.2 – User needs and requirements on a digital transport system, p. 197 (2020)

Vecchio, G., Martens, K.: Accessibility and the capabilities approach: a review of the literature and proposal for conceptual advancements. Transp. Rev. **41**(6), 833–854 (2021). https://doi.org/10.1080/01441647.2021.1931551

Velaga, N.R., Beecroft, M., Nelson, J.D., Corsar, D., Edwards, P.: Transport poverty meets the digital divide: accessibility and connectivity in rural communities. J. Transp. Geogr. **21**, 102–112 (2012). https://doi.org/10.1016/j.jtrangeo.2011.12.005

W3C. Web Content Accessibility Guidelines (WCAG) 2.0 (2008). https://www.w3.org/TR/WCAG20/

W3C. W3C Accessibility Guidelines (WCAG) 3.0 (2021). https://www.w3.org/TR/wcag-3.0/

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