A Serious Game as a Tool for User-Centered Design of Mobility Solutions

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Abstract. Before the implementation of new mobility solutions, it is often difficult to encourage and enable potential users to participate in the design process, to predict acceptance, and to determine the influence of individual design parameters on use intentions. A serious game involving repeated mobility choices and, at the same time, fun to play might be a useful tool to allow for user studies and participation in this situation. We developed a concept of such a game in the context of intermodal transport. A first prototype was implemented and subjected to an early test with respect to user experience and usability through an evaluation with seven experts. At the current state of development, flow experience, measured by the flow short scale (FKS), was medium. Usability, measured by the system usability scale (SUS), was low, and the heuristic evaluation yielded many hints for improvement. Based on the insights gained, the development of the game will be continued to prepare it for a user test assessing the potential of the method for studying user preferences in the transport system.

Keyword: user design methods · intermodal networks · early prototyping

1 The Challenge of User Participation in Early Design Phases

1.1 Motivation

Before the introduction of new mobility solutions, it is often difficult to enable potential users to participate in the design process, to predict their overall acceptance of the to-be-developed solutions, and to determine the influence of individual design parameters on use intentions. This difficulty arises from the multitude of design options and potential interactions of design, user and context characteristics, while, at the same time, it is difficult to convey a vivid idea of how it feels to use the mobility solution, or another product or service, respectively. Moreover, it is often a challenge to encourage users to participate early in the design process.

Within the framework of the DLR project "Connected Mobility for Livable Places", we aim to develop a new method for exploring user preferences in mobility and involving users more actively in early phases of the design of mobility solutions. The practical

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problem we address is the attractiveness of intermodal transport links to users. Given the EU's defined climate targets, particularly the goal of carbon neutrality by 2030 [1], there is an imperative need for sustainable changes in mobility. One approach to reduce emissions in the traffic sector is to shift traffic volume from motorised private transport to non-motorised transport modes and public transport. In order to continue to meet people's mobility needs in the process, it is necessary to understand users' pain points and requirements with regard to the intermodal transport. Furthermore, it would be useful to have a virtual laboratory by which the effects of changes in the transport system on user acceptance can be studied without having to implement them in the real world. A serious game appears to be a promising approach for these purposes.

1.2 Serious Games as a Research Tool

It is challenging to establish a consistent definition of the term *serious game* because serious games are applied with various objectives and heterogeneous approaches across multiple disciplines [2]. According to Michael and Chen [3], serious games can, in general, be described as "games for purposes other than entertainment". Among other things, they offer a motivating environment to present and teach specific skills and knowledge. They are used, for example, in the areas of healthcare, public policy, strategic communication, defence, training and education, stealth assessment, and citizen science [4].

The features of serious games that are of interest in the context of our research are as follows: (1) serious games offer the possibility to depict a complex world with its relevant elements and effective relations, (2) they allow users to interact with this world and experience the consequences of this interaction, (3) features of elements and relations in the game world, such as design features of mobility options and context variables, can be changed systematically and with relatively little effort, (4) this allows for experimentation in context and the analysis of how user preferences and behaviour change depending on the design of the world, and (5) users have an intrinsic motivation to engage in the interaction. This combination makes serious games an interesting alternative to traditional methods of user research as, for example, interviews, surveys, or classic choice experiments, which are usually only moderately fun to the participants. Often, additional external incentives are required to encourage participation. The acceptable duration of assessment and thus the amount of data that can be assessed are limited. Moreover, it is often difficult to give the users a vivid understanding of mobility variants that are not available in reality so far.

In order to make the choices that users make in a serious game a valid reflection of real decisions, it is important that the relevant incentive structures of the real world are reflected in the game. For example, research has already shown that the travel duration and the price associated with a given mobility option are important features for user decisions [5]. Therefore, as in reality, a subjective cost needs to be associated to these features of a mobility option in the game, too. This can be achieved, for example, by assigning a duration to the act of traveling in the game that is proportionate to the time that would be needed in reality, and by introducing a currency to the game that can be used to acquire equipment useful to the character and that also needs to be spent for mobility. For the methodological development of our game, we have two consecutive

goals. At first, we want to create a game world that replicates the incentive structure of the current mobility system as realistically as possible. If this is successful, the game can be used to study the effects of any constellation of design and context variables that is of interest.

2 Conceptual Design of the Game

2.1 Methodological Framework

The game is intended to be both a research tool to understand the rules governing user acceptance of mobility offers, and a design tool to study user acceptance towards new design options. The methodological framework is a choice experiment [6]. This method allows to determine the relative importance of design parameters and other variables for user choices and can also be used to investigate "what-if" questions related to the design of new products and services, such as the design of intermodal transportation links. Our approach considers all three major sources of variance in acceptance: system design, context, and user characteristics. Variables of system design and context will be purposefully varied in the game. The dependent variable is the user's resulting mobility choice. User characteristics with potential relevance for mobility behavior will be assessed as control variables.

2.2 Game Concept

In the game, players have to repeatedly choose one of several mobility options to reach their destination in order to realize their missions. Players assume the role of an up-and-coming influencer, striving to amass as many followers as possible. To achieve this, they travel to different locations in order to capture photos adorned with trending hashtags. The game starts in the influencer's home. Upon waking up, the player is prompted with currently trending hashtags (such as #Pumpkin), current weather conditions, a promising destination, and the required luggage. Considering the circumstances, as well as the cost and duration, the player chooses from a variety of transportation options. After stepping into the outside world, the player is presented with an animated sequence featuring the selected mode of transportation and environmental conditions. The animation's duration corresponds to the chosen mode of transportation, for instance, cycling takes longer than driving a car. Upon arriving at the destination (e.g., a cafe), the player's task is to take a photo, with the aim of including as many hashtags as possible in the photo, as this attracts more followers. The photo mode is creative, allowing the player to adjust focal length, aperture, and filters. After taking a photo, the player can "post" it on a virtual social media platform. Transitioning back to the apartment through the transportation animation, the player is presented with a reward screen displaying the increase in followers and virtual currency, essential for affording various modes of transportation. Finally, the player heads to bed, before a new day with photo challenges starts. See Fig. 1 for some impressions from the game.

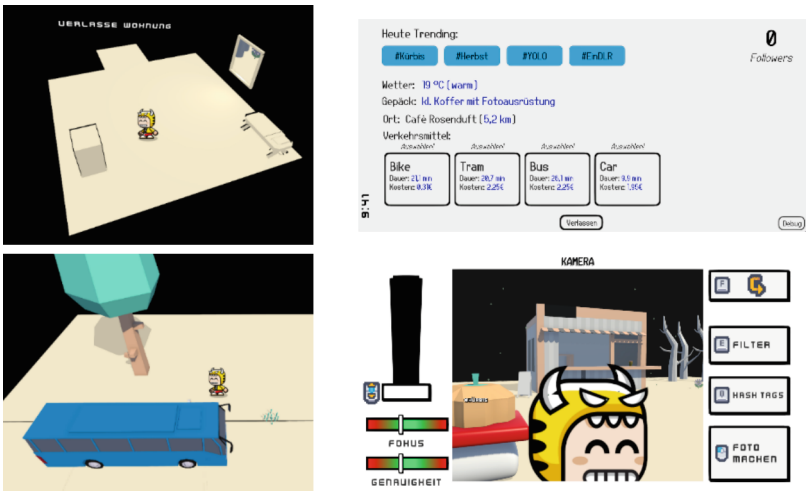

Fig. 1. Screenshots from the game prototype. Top left: About to leave the house. Top right: Learning about currently trending hashtags, the context of travel (weather, luggage, destination, distance), and the available mobility options. Bottom left: On my way! Bottom right: Taking the selfie at the trending location and with the trending objects. Copyright 2024 by DLR.

2.3 Study Design

The possibilities for varying service and context characteristics of the travel in the game are considerable: From potentially relevant variables and their conceivable levels, thousands of combinations are possible. For development, the following independent variables were chosen: weather, with temperature (–1°, 8°, 19°, 31°) and precipitation (yes vs. no), luggage (none, backpack, photo suitcase, both), travel distance in km (0.8, 2.1, 5.2, 12, 19) means of transportation (foot, bike, pedelec, e-scooter, bus and tram, car, train), travel duration, and price. For the latter two, three levels (low, medium, high) are implemented whose exact values will vary depending on the travel distance and the means of transportation. The medium values for these combinations have been researched to reflect realistic values in the current transportation system in Germany; the low and high values are derived from the medium ones by subtracting or adding 10%. User characteristics (e.g. age, gender, mobility habits) will be assessed as additional variables to include in the analyses.

3 Implementation of the First Prototype

We develop the prototype using the Unity game engine. To reach a high number of potential participants, we chose the web browser as our target platform, in order for the prototype to run independently of the operating system (e.g., Windows, iOS, Android, or Linux). This way, participants do not need to install the prototype on their system to use it. We host the game on a DLR website to ensure data protection and make sure that everyone is playing the same version after updates. This allows us to change conditions during an evaluation, for example. Each participant receives a random identifier and

after each play session, a list of all decisions and conditions together with the identifier are sent to a database.

4 First Prototype Evaluation: User Experience and Usability

A first evaluation of the prototype was done with respect to user experience and usability with experts from DLR. Participants were instructed to play three rounds of the game, provided via a web link. After that, they answered the flow short scale (FKS) [7] and the system usability scale (SUS) [8] with regard to their experience in playing the game. After the experience sampling, participants were asked to do a heuristic evaluation concerning the usability of the prototype [9]. They were instructed to click through the game again and consciously look out for elements, features or design decisions that violate one of the 10 usability heuristics that were listed and briefly explained on the same page. Participants were asked to note their observed problems and make recommendations on how to fix them. Finally, they were asked to go through all the problems again and provide a rating for each one, from *0 = I don't think this is a problem at all* to *4 = Usability disaster: must be fixed before the product can be released.*

5 Results

Seven experts took part in the evaluation. All worked at DLR. Their age ranged from 24 to 46 years ($M = 33.0$, $SD = 8.3$), four were women, three men. Their fields of expertise comprised human factors, usability and user experience ($n = 6$), or development of interactive applications ($n = 2$). Three are part of the author team.

Overall *flow* experience, as measured by the FKS seven-point scales, was mediocre ($M = 3.8$, $SD = 0.6$), mirroring nearly equal scores on the two flow subscales s*mooth automated progression* ($M = 3.8$, $SD = 1.0$) and *absorbedness* ($M = 3.9$, $SD = 0.8$). *Concern* was very low ($M = 1.5$, $SD = 0.5$). Participants' ratings on the FKS nine-point scales concerning subjective difficulty of playing the game ($M = 2.6$, $SD = 1.5$) and task demand ($M = 2.6$, $SD = 1.5$) ranged from low to medium. Self-assessed ability in playing computer games was very heterogenous in the expert sample, however with a majority of values in the lower part of the scale ($M = 3.7$, $SD = 2.1$).

SUS scores for overall usability of the game prototype ranged between 30 and 45 ($M = 38.7$, $SD = 4.9$). This result needs to be interpreted as representing poor perceived usability of the prototype so far [10].

The results of the heuristic evaluation can only be presented in overview. Not all participants provided severity ratings; therefore, results are ordered here by the number of individual mentions of problems. These can touch the same problem, that was reported by multiple participants. Most individual mentions related to a lack of clarity about the tasks and the options and interaction possibilities in the game, and a lack of exits from different situations. A medium number of comments related to the situation that, so far, nothing prevented the character from falling into nothingness when they reached the outer rim of the game environment, and that apart from the tutorial, there was no help information available so far. A number of mentions referred to non-consistent availability of information on how to interact with the game, poor legibility of the font

used, inconsistent use of languages, and so far non-existent error messages and solution options offered by the system in case of errors. Individual comments referred to the inputs used to control the game, the possibility to provide more keyboard shortcuts, and the complexity of the map used to visualize the route options in the game.

6 Discussion and Outlook

We developed a concept for a serious game to assess user preferences in mobility. A first prototype of the game was implemented and tested through an expert evaluation.

The results show a lot of possibilities for improvement. This is not surprising at the current state of development, since the prototype was tested once it had first reached a playable status. The early evaluation is part of the planned development process. The results give the development team valuable insights on how to optimise the game in terms of user experience and usability, in order to maximise its potential as a research tool. The next steps will be another usability and user experience test conducted with users, in which also the functions for data assessment will be consolidated. After that, the game will be rolled out to test the potential of the method for studying user preferences in the transport system.

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