Transportation Research Interdisciplinary Perspectives 3 (2019) 100079

Contents lists available at ScienceDirect

Transportation Research Interdisciplinary Perspectives

journal homepage: https://www.journals.elsevier.com/transportation-research-interdisciplinary-perspectives

Introducing a mobility on demand system to prospective users with the help of a serious game

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ARTICLE INFO

Article history:
Received 22 August 2019
Received in revised form 21 November 2019
Accepted 23 November 2019
Available online 4 December 2019

Keywords:
Serious game
Gamified learning
Knowledge transfer
Mobility on demand
Diffusion of Innovation Model
Technology Acceptance Model
User acceptance
Interdisciplinarity

ABSTRACT

Sustainable mobility concepts are challenged to create a positive users' attitude and a high willingness-to-use to be adopted and survive on the market. Prospective users must not merely be informed about the service but become involved and feel affected. The contribution introduces a digital learning game, a so called serious game, to improve players' knowledge, attitude and willingness to use mobility on demand systems (MODS). The goal of an evaluation study in a high school (N = 71) was to compare the serious game and an online research according to the proposed effects on knowledge, attitude and usage intention. The study demonstrates that pupils' level of knowledge about the operational concepts of MODS increased after playing the game and the retention rate was higher. Playing the game furthermore resulted in a more positive appraisal of MODS concerning their usefulness. No significant effect of the serious game on the later usage behaviour was found. The paper points out the benefits of a gamified approach for introducing mobility services to prospective users and derives recommendations for the application of gamified approaches to facilitate the adoption of new technology or services.

1. Introduction

1.1. Challenges in the introduction of mobility on demand systems

Today, digitalization and automatization enable a variety of additional degrees of freedom for the provision of mobility on demand (Savelberg et al., 2017). Thus, we are witnessing the rapid dissemination of new means transport and associated services, like e-scooters or ridehailing, driven by the users' requirements for flexible and on-demand mobility. The article focusses on one of these new transport services – mobility on demand services that use dynamic ridepooling algorithms to either replace or complement public transport systems in areas and times of low demand by adapting their routes to the actual demand (Mulley and Nelson, 2009). Mobility on demand systems services (MODS) are in large parts very different from fixed-scheduled public transport since they can be defined as "an intermediate form of public transport, somewhere between a regular service route that uses small low floor buses and variably routed, highly personalised transport services offered by taxis" (Brake et al., 2004; p. 324). It can be assumed that prospective users' knowledge about the operation concept and service model of MODS is limited if they have not made any experiences with the service. Thus, before starting to operate new MODS, it is a wise approach to study the factors that might facilitate their adoption as well as usage barriers that prevent people from using MODS systems (König and Grippenkoven, 2019a, 2019b). A study that investigated the reasons for the discontinuance of the MODS *Kutsuplus* in Helsinki revealed that the inhabitants' information lack concerning how to use the service and the lack of awareness about the service were the main reasons for not having used the service (Weckström et al., 2018). Accordingly, the authors recommend that "[…] marketing strategy should reflect the end user target group, and aim at education on how to use the service" (Weckström et al., 2018, p. 96). In a household survey to examine residents' perception of a local demand-responsive transport system (DRT) that are comparable to MODS, Nelson and Phonphitakchai (2012) found that respondents have a low level of knowledge about the places served by the DRT service and showed that respondents' negative appraisal of the service was linked to a misunderstanding of the underlying service concept. Accordingly, Beirão and Cabral (2007) figured out that missing or insufficient information are a relevant barrier for using public transport in a qualitative study. Accordingly, Laws (2009) points out "[…] some of the DRT schemes included were not achieving the expected usage levels because potential passengers did not fully understand who the service was for, what the service was for or how to use the service." (Laws, 2009, p. 240).

It is assumed, that meeting the users' requirements to a high degree with a user-centered service concept of MODS is a necessary but not a sufficient

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http://dx.doi.org/10.1016/j.trip.2019.100079

precondition to achieve a high users' acceptance and willingness to use the system (König et al., 2017). Creating awareness and a sufficient understanding in the target group appear to be a key factors for the success of a new transport system. Therefore, three major challenges have to be considered as an early part of an effective and sustainable adoption process of new MODS:

1. A challenge of *sufficient conceptual comprehension*: referring to the prospective users' awareness and understanding of the operation concept, especially the flexibility of MODS and the necessity of dynamic routing results. An insufficient provision of information about how to use the mobility service or the absence of a transparent and understandable information environment could result in a refusal of the mobility service (Finn et al., 2004).
2. A challenge of *favourable appraisal*: as the intention to perform the behaviour in question can primarily be predicted from a positive attitude towards the behaviour (Ajzen, 1991), achieving a favourable appraisal of the MOD system is a necessary precondition for its acceptance and subsequently adoption. Especially, the perceived usefulness of a transportation system contributes to a favourable appraisal of DRT systems as shown by König and Grippenkoven (2019a).
3. Third, a challenge of *acceptance*: referring to the finding that a favourable assessment of a system or service is a necessary but not a sufficient precondition for its adoption (Dethloff, 2004). Thus, the transition between the preactional and actional stages that mark the phase of behavioural intention (Bamberg, 2013) must be facilitated by an active willingness to use the service (Ambrosino et al., 2003). Hence, to encourage people and to provide strong incentives to try out and experience the new system is of great relevance for facilitating the adoption process. Finding effective solutions for supporting citizens' adoption of sustainable mobility behaviors is an important challenge of present day's research (Gabrielli et al., 2014).

To face the named challenges, MODS should be first of all introduced to the prospective users in a comprehensive manner since empirical evidence proves the necessity. Furthermore, the model of self-regulated behavioural change of Bamberg (2013) suggests that individuals at an early, predecisional stage should be a target of interventions for activating problem awareness and perceived personal responsibility (Bamberg, 2013). For achieving prospective users' favourable attitude towards MODS it seems necessary to increase its perceived usefulness by underlining the individual, societal and environmental benefit of the new concept. Traditional means of raising awareness and facilitating understanding and a favourable appraisal concerning new transport systems are the word of mouth (Laws, 2009), internet homepages (Moia, 2019), flyers and instructions at the bus stops (Landkreis Teltow-Fläming, 2010) or articles in the local newspapers (Neumann, 2018). Yet, to master the named challenges when introducing innovative mobility services, new interactive and digitally based approaches might be a beneficial way to bridge the gap between dissemination and adoption.

1.2. Game-based learning

Games have always been an important element of culture in human evolution and have been used since thousands of years as an interactive learning environment for competition, cooperation and skill acquisition among others (Kriz, 2003). So called *Serious Games* are characterized by "a thought-out educational purpose and are not intended to be played primarily for amusement" (Abt, 1970, p. 9). The term is often used interchangeably with *edutainment games*, *games for behavioural change* and *persuasive games* among others (Antle et al., 2014; Crookall, 2010). Serious games are mainly used for game-based learning, but also for other purposes such as to initiate behavioural change (Bogost, 2010). Serious games should be differentiated from simulations that display reality as precise as possible whereas serious games reduce the complexity of the reality in the game model and thus offer a higher number of degrees of freedom (Freese et al., 2019).

Several empirical studies from different research domains confirmed the effectiveness of game-based learning, compared with conventional instruction methods. The studies found higher retention rates concerning declarative knowledge and procedural knowledge and greater learners' interest in the topic when introduced to game-based learning methods (Randel et al., 1992; Sitzmann, 2011; Tennyson and Jorczak, 2008; Wouters et al., 2013). Gamified approaches as an umbrella term for serious games, gamification and simulation games among others proved to support knowledge acquisition and content understanding in different domains as shown in a literature review conducted by Connolly et al. (2012). Game-based learning was also found to support players' positive appraisal (Connolly et al., 2012) and to prompt behavioural change (Klimmt, 2009; Soekarjo and van Oostendorp, 2015).

The power of games for facilitating learning processes can be traced back to the fact that games base on the same features like effective learning environments – they are engaging, situated and problem-based, ensure the learners attention, provide continuous and immediate feedback and an appropriate level of challenge (Boyle et al., 2011; Shute, 2011). Well-designed serious games encourage players to interact with the game world, experience mechanisms and concepts of complex socio-technical systems and thus become instrumental tools to support knowledge acquisition, help to change attitudes and encourage long-term behavioural change (Bogost, 2010; Hung and Van Eck, 2010).

1.3. Gamified approaches in transportation

Transportation systems are characterized by their high complexity and dynamic those are based on the large number of actors and interdependencies in socio-technical systems (De Bruijn and Herder, 2009; Mayer et al., 2010). Thus, interactive games are a promising approach to depict the complexity and dynamic of transportation systems. Accordingly, games and gamified approaches enjoy growing popularity in the last few years. Games in the transportation domain are mainly used as persuasive games to change players' mobility behaviour or transport mode choice, like the gamification approach *Streetlife*, that aims introduce new mobility services in pilot sites (Kelpin et al., 2016) or the game INSCINC that was developed to reduce peak demand in public transit (Pluntke and Prabhakar, 2013). There are also some examples of serious games in transport domain to facilitate learning about transport systems like the *Unilink Bus Game* (Yusoff, 2010) that aims to make international students of the University of Southampton familiar with the bus system. The simulation game of Wittowsky (2009) represents an example how games are used in transportation research to assess and quantify the effects of new technologies on the transportation system. Frequently, so called simulation games are used as a mean to discuss transport and infrastructure planning with transportation and land use experts or other stakeholders or to train stakeholders how to handle disruptions in the transportation network (Klemke et al., 2015). Another example is *SprintCity*, a multi-player game that is intended to be played with experts in the field of rail transportation (Duffhues et al., 2014). There is also a broad and growing branch of research assessing the potentials of gamification that is defined as the use of game element in other contexts, to incentivize behavioural changes towards sustainable mobility solution and mode shift (Kazhamiakin et al., 2015; Liyanage et al., 2019).

The review of gamified approaches in transportation research reveals a growing interest of science and practitioners in applying games for different purposes. Yet, these applications of gamified approaches often lack a systematic theoretical foundation and a comprehensive evaluation of their desired impacts and side effects. Furthermore, the literature review reveals a lack in empirical findings regarding the use of gamified approaches for facilitating the introduction of new mobility services, such as MODS.

1.4. A theoretical framework for the evaluation of game-based learning

Literature acknowledges the proposed positive effects of gamified approaches on learning, attitude or behaviour, yet, the empirical validation

of its effectiveness is fragmented and sparse (Van der Kooij et al., 2015) and the "discourse has largely remained at a conceptual level" (Ritterfeld et al., 2009, p. 691).Whereas psychology and social science have a long tradition of developing evaluation tools and measures, only few validated tools exist for the assessment of play-specific experiences and its effects (Van der Kooij et al., 2015). As one possible approach the introduction of new MODS can be understood as the task to make users accept a new transport technology (Chen and Chao, 2011). Thus, Yusoff (2010) used the Technology Acceptance Model (TAM, Davis, 1989) to evaluate the serious game *Unilink Bus Game* that introduced international students to public transport in Southampton. The model describes two direct factors of an individual's attitude towards a product or service: the *perceived usefulness* and the *perceived ease of use* (Davis, 1989). The theory proposes a favourable attitude to be a direct antecedent of the behavioural intention to use a product or service which in turn is the only direct determinant of the actual use behaviour.

Another approach to evaluate the effectiveness of game-based learning comes from citizen participation that often use gamified approaches to involve citizen as games provide an interactive instrument to inform and involve citizens and asses their needs (e.g. De Lange, 2015; Meloni and Antunes, 2017). Civic engagement and participation in transport planning is based on the idea to think about citizens as planners rather than mere consumers and thus involve them in the co-creation of solutions for sustainable transportation (Sagaris, 2014). Yet, the effects of participation on the local transport plan process are rarely evaluated (Bickerstaff et al., 2002). The difficulty of measuring change process due to participation processes (Gebhardt et al., 2019) and the need to conduct evaluation studies are outlined in the existing literature (Rowe and Frewer, 2004). Approaches of citizen participation and gamified approaches share the common element of a highly complex research objective. The complexity of the research objective requires evaluation methods that give regard to this and consider the temporal course of the development and the adoption of ideas and innovation in the real-context. Kebritchi (2010) applied Roger's theory of Diffusion of Innovation (DoI) to the adoption of computer games (Rogers, 2003). The DoI is one of the most prominent theories concerning the distribution of technological innovations in society and empirically well established. The theory has also been applied to mobility research (Keller et al., 2018). The DoI theory appears useful for assessing the adoption process of a new mobility service. The theory is based on the premise that diffusion, is distributed over five stages, that might serve as a reasonable basis for user tests (Rogers, 2003). These stages are *knowledge*, *persuasion*, *decision*, *implementation* and *confirmation* and a preceding stage concerning *prior conditions* as social norms or experiences (Rogers, 2003). According to the theory, the individual adoption process of an innovation starts with the knowledge phase, where the individual is first exposed to an innovation, but has not made any experiences within the system. The knowledge phase is thus an essential prerequisite for the following phases of adoption. Rogers differentiates between three kinds of knowledge concerning an innovation: 1) awareness knowledge: the conscious perception of an innovation, 2) how-to-knowledge: knowledge about the functionality and manner of utilization and 3) principles knowledge: the understanding of subjacent processes and background information.

The study at hand integrates the theoretical frameworks of the Technology Acceptance Model and the Theory of Diffusion of Innovation to a research model as done before (Agag and El-Masry, 2016; Lee et al., 2011). As presented in Fig. 1, the DoI is expected to complement the rather condensed TAM with further determinants of the use behaviour. It is also expected that the integration of the two models better reflects the adoption process. The resulting research model is used for the evaluation of the effectiveness of a serious game for increasing the knowledge and conceptual understanding about mobility on demand systems and facilitating its positive appraisal as well as raising the usage intention.

1.5. Research aim of the paper

The paper at hand adapts a game-based learning approach for introducing mobility on demand systems to prospective users by addressing the challenges named of *sufficient conceptual comprehension*, *favourable appraisal* and *acceptance*. The named challenges are reflected by the proposed research model (Fig. 1) in a way that the knowledge phase addresses the challenge of sufficient conceptual comprehension, whereas the persuasion phase deals with the challenge of a favourable appraisal and the decision phase with the acceptance challenge respectively. More specifically, the paper presents the serious game *B.u.S.* (*Bürger unterrichten durch Spiele*, engl.: Teaching citizens through games) that was developed to enhance players' knowledge, attitude and subsequently behavioural intention for mobility on demand systems. The game's effectiveness as an experiential learning tool was assessed with the help of an experimental evaluation study. Even though the game was developed for different user groups aged from 10 to 99 years, the target group of the study were high school pupils as being aged between 15 and 24 years was found to be a key target group of DRT services in Australia in a literature review (Jain et al., 2017). Adding onto this, mobility on demand systems that often fail because of low usage rates as found by Enoch et al. (2006) for Great Britain might benefit from addressing the target group of children and teenagers as they

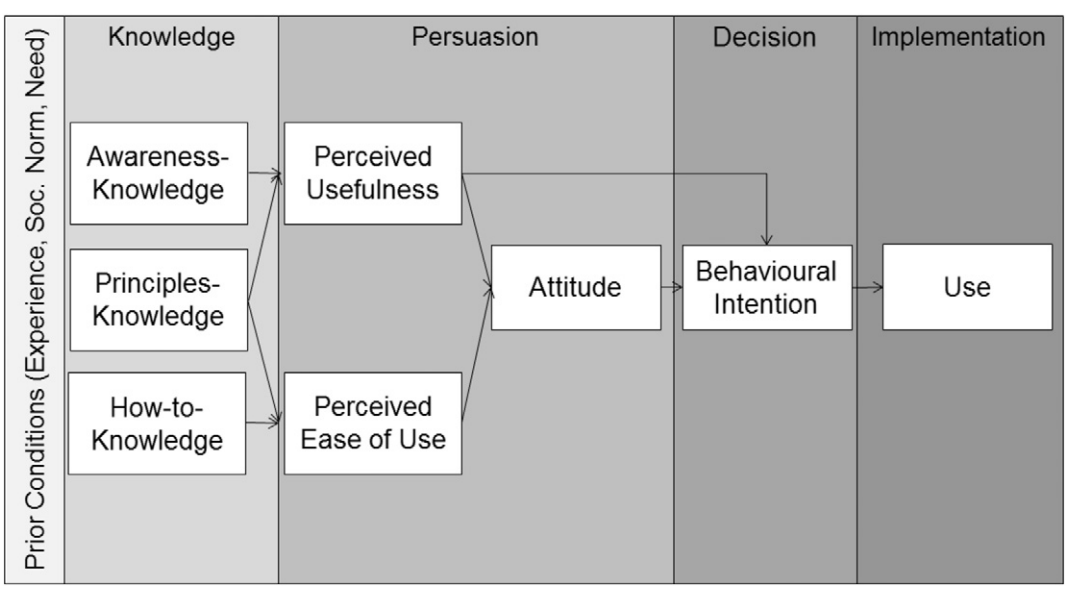

Fig. 1. Research model based on the Technology Acceptance Model (Davis, 1989) and Diffusion of Innovation (Rogers, 2003).

represent a relevant share on regular mobile persons. Pupils living in rural areas of Germany travel on average 9 km to school (Nobis and Kuhnimhof, 2018). In Germany, 8% of every trip is an accompanied way, mostly conducted by parents and their children (Nobis and Kuhnimhof, 2018). Reducing the number of accompanied trips is an ambitious goal towards more environmentally sustainable and self-determined mobility of adolescents. Another reason for focussing on teenagers as target group lies in the fact that the teenagers of today will be the grown-ups of tomorrow and will affect the transport system with their modal choices. Above this, targeting adolescents is seen as an effective strategy in einfluencing the attitudes and change processes of younger and older generations as young people are currently exerting mighty behavioural influence on their parents (Arthur D. Little and UITP, 2014).

2. Methods and materials

2.1. The serious game B.u.S.

The serious game *B.u.S.* was developed based on the *Contextual Design* approach by Holtzblatt et al. (2004) that is characterized by a systemic, user-centered and prototype based development process. *B.u.S.* was created and developed by an interdisciplinary team of two game designers, a psychologist, a human factors specialist and a computer scientist with the game engine *Unity Engine* (Unity Technologies, 2019). The game was developed based on an iterative process that included loops of testing and adjustments of early prototypes (Fig. 2). Usability tests were conducted during the design phase with the help of the methods of Thinking Aloud (Dumas, 2001) and a Heuristic Evaluation (Nielsen and Molich, 1990).

To meet the challenges of the introduction of new mobility services (Section 1.1) the mobile game *B.u.S.* was designed as single-player role game that puts the players in the position of a public traffic planner (König et al., 2017). Role-play games have proved to elicit empathic responses from player sas they uniting their goals with that of their protagonists and make the players reflect about the perspective of the role (Jacobs et al., 2017). Learning through role play was applied for different learning purposes and has shown to improve player's cognitive and emotional involvement (Colucci-Gray, 2004). With the help of the role-game, players were forced to adapt the role of a traffic planner and leave the egocentric perspective of users. Thereby, the player should experience the complete picture of the transport system. Bogost (2010)) uses the term *procedural rhetorics* for persuasion through rule-based representations and interactions rather than direct speech. In this way, the players were encouraged to experience the transport system according to the Exploratory Learning Model (De Freitas and Neumann, 2010). The players of *B.u.S.* thus explore a virtual city and the residents' mobility and operate a mobility on demand system that serves the mobility needs of different residents. The player's task is to route the MODS vehicles according to the actual needs of the travelers and pick them up at a variety of stops and transport them to their desired destinations. To reflect the complexity and heterogeneity of passengers' demands the game concept uses different colored figures that illustrate the desired destination of the travelers (Fig. 3). Furthermore, players are encouraged to meet the goal of an efficient and environmental friendly operation. It is supposed that the players are enabled to understand the logic of operational planning and become aware of the effects of traffic planning by routing the on-demand vehicle. Thereby the challenge of sufficient conceptual comprehension is addressed.

The game concept of *B.u.S.* is level-based with new and increasingly difficult mission goals that force the player to explore the actual game situation. At each level, the player is confronted with a challenge that can only be solved through goal-directed exploration of the simulated system. An evaluation screen provides feedback about how successful the player's solution was based on a rating with asterisks and textual description (Fig. 3, bottom). During game play immediate feedback about the MODS performance is given by dynamic bar charts that display the waiting time of travelers and the ecological friendliness of the service due to a low number of empty runs. Furthermore, feedback on the passenger's satisfaction according to low wait times is operationalized by using frown smileys as shown in Fig. 3. In order to demonstrate the differences between fixed-scheduled bus transport and MODS and to demonstrate the benefits of flexible routing, a public bus is introduced in level 4. The public bus serves fixed bus stops and operates in a fixed-scheduled manner. Players are encouraged to complement the public bus by demand-driven operation of the MODS and are expected to learn the differences of the operational concepts of both transport services by the direct comparison.

The players are expected to elicit a favourable appraisal of the new bus system, addressing the second challenge, by demonstrating the positive effects and benefits of MODS for the passengers, the transport company, the society and the environment as well. The experiential game approach encourages the player to actively deal with the new system and experience system functions and constraints. The active component of the game is meant to increase the player's willingness to use the new bus system, thus addressing the acceptance challenge. For transferring the acquired knowledge to the daily life and to improve the willingness to use the bus system an extensive debriefing was part of the gaming experience (Crookall, 2010).

2.2. Participants

The study's participants were pupils of 10th to 12th grade (N = 71) of a high school in Luckenwalde, a small town in Brandenburg, Germany. The location was chosen as an on demand system called *Rufbus* operates since 2010 in the study area (Landkreis Teltow-Fläming, 2010). Residents of the districts of Nuthe-Urstromtal can use the transport system every day from 05:30 to 21:30 and at the weekends from 08:30 to 21:30. The pupil were recruited with the help of the school administration. The evaluation study was conducted in three different clases that were teached by the same teacher to control for this variable. The experiment was performed during a regular class thus avoiding self-selection effects due to voluntary participation in the leisure time. Hence, it can be assumed that the participation was somehow mandatory.

Tthe mean age of the sample was 16.75 years (SD = 1.07). Gender was equally distributed among the sample (female = 36, 50.7%). Every

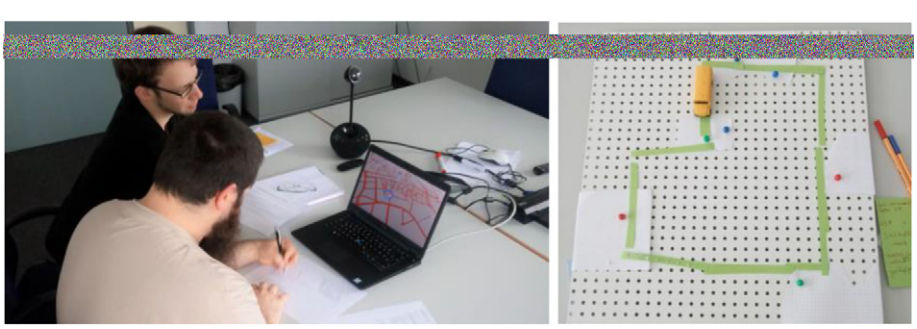

Fig. 2. Left: Heuristic evaluation of the game's usability. Right: Early prototype of the game.

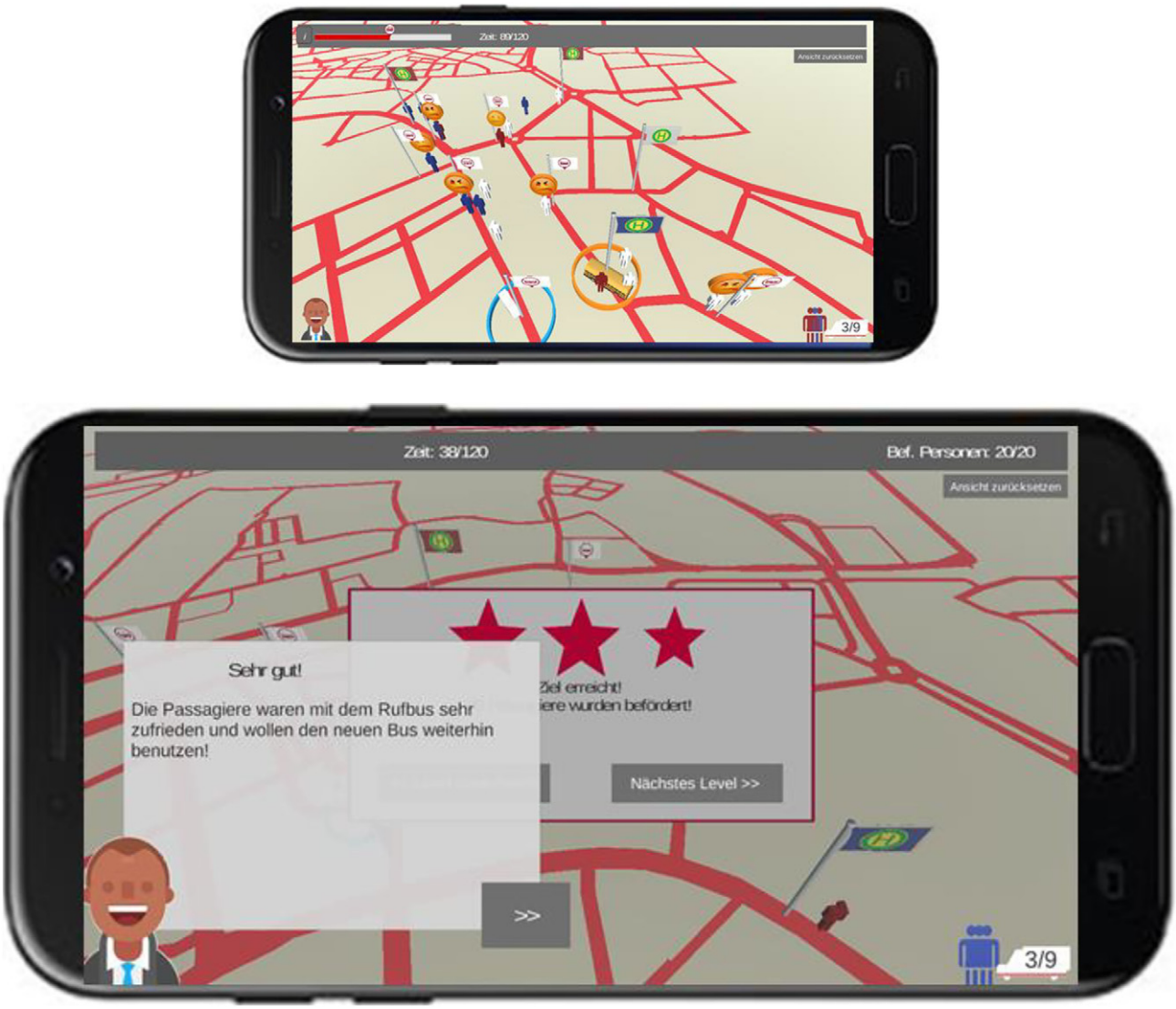

Fig. 3. Screenshots of the mobile game *B.u.S.* Top: Gaming situation at level 4 with an additional fixed-line service, Bottom: feedback site with evaluation screen.

participant stated to own a smartphone (100%) and 42.3% (n = 30) specified to own a tablet. The majority of the participants stated to be online for at least 60 min per day (91.5%, n = 65). Concerning their game play experiences, about three fourths of the participants specified to play games at least several times per week (76%, n = 54). Five participants stated to play no games (7.0%). The share of participants' game experiences was equally distributed among the two experimental groups. Concerning the most used transport mode for daily trips to school 43.7% (n = 31) specified bus transport, bike by another 29.6% (n = 21). The private car was used as a driver by 14.1% (n = 10) and as car passenger by another 5.6% (n = 4) as most frequently used means of transport for school trips. Walking was specified by 7.0% (n = 5) to be the most frequent mode for trips to school.

2.3. Material

The study was accompanied by three questionnaires: 1) a pre-test, 2) a post-test and 3) a second post-test. Each questionnaire based on the same questions regarding the knowledge about MODS, attitudes towards MODS concerning the perceived reliability, price, speed and environmentally friendliness adapted from Chen and Chao (2011). For measuring the TAM constructs Perceived Ease of Use and Perceived Usefulness, the items from the were adapted to the context of DRT. Additionally, the pre-test consisted of questions regarding sociodemographic characteristics, mobility behaviour and prior experiences with the local MODS *Rufbus*. The post-test included questions concerning the game and online research experience, respectively. The second post-test consisted of additional questions regarding the usage of the *Rufbus* during the last weeks.

For the questionnaires, 5-point likert scale questions and open questions were used.

2.4. Study design and procedure

The study design entails a classical repeated measures design with a control group (Hainey, 2010). The first post-test was conducted directly after the intervention. To investigate the knowledge retention over a medium period of time a second post-test was conducted four weeks after the game session (Catalano et al., 2014). The experimental design of the evaluation study is shown in Fig. 4.

After a written pre-test (T1), the participants were randomly assigned to either the experimental group or the control group with the help of drawing sweets from a *Celebrations*® box. In a separate classroom, the experimental group was introduced to the serious game *B.u.S.* and played the game for 15 min on smartphones or tablet computers (Fig. 5). Subsequently, they did a 5-min written reflection on the game and what they have learned since the reflection and debriefing phase is seen as a very important component of gamified learning to facilitate the knowledge transfer

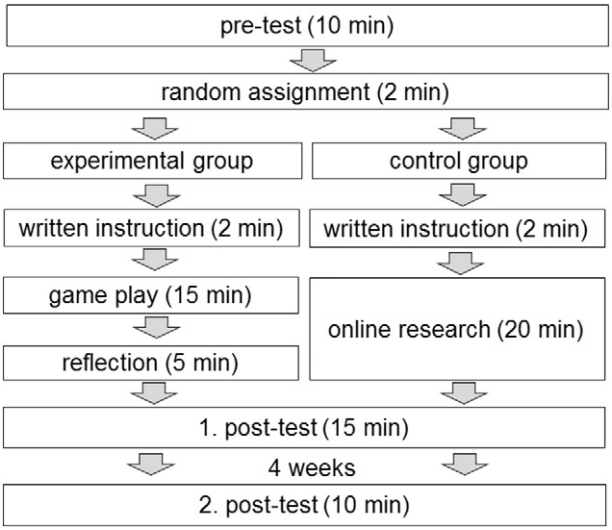

Fig. 4. Experimental design.

from the game to the real world (Crookall, 2010). Three open questions were used to facilitate the reflection (*Shortly describe your task in the game. Which experiences have you gained by playing the game? Which is your main lesson learned after playing the game?*). In the meantime, the control group was encouraged to inform themselves about mobility on demand systems with the help of an online research with tablet computers or smartphones (20 min). The online research was chosen as a comparative measure to the game as they share relevant characteristics as the medium and the familiarity for the target group. Furthermore, the online information-seeking is a very common way of adolescents to obtain information (Micheli, 2015). After the game or respectively the online research session, the participants completed the post-test questionnaire (T2). After four weeks, they were handed the second post-test questionnaires (T3).

3. Results

In the following section, the study findings are presented according to the stages of the research model (Fig. 1). First, the developed game is assessed due to its perceived difficulty and fun as a mean for plausibility check and a control for the internal validity. Game's difficulty was assessed as medium difficult (M = 2.86, 1 = very difficult; 5 = very easy), showing a wide span of players' assessment (SD = 2.3). Four participants (n = 10.8%) experienced concrete difficulties in the handling of the game (too small textual descriptions and unawareness about the possibility to move the city map). The majority of the players played the game up to level 4 of 6. The analysis of the question regarding the experience of fun during the game play showed that participants enjoyed playing the game and experienced fun (M = 3.94, SD = 0.94,1 = very little fun; 5 = a lot of fun).

For the statistical analysis, a repeated measurement analysis of variance (ANOVA) was used to analyze the differences among the group means between the different points in time. Basically, ANOVA assesses whether or not two or more means are equal and is relatively robust against violations of its assumptions (Field, 2009). ANOVA are applied when more than two groups are regarded. For the analysis of the intervention effect between the control group and the experimental group, t-tests were used (Field, 2009).

3.1. Prior conditions

Prior conditions form a preceding stage of the 5-stages research model and comprise of previous experiences and social norms (Rogers, 2003). Concerning their previous experiences with the local MODS, the share of pupils that have used the *Rufbus* before was small with 7.0% (n = 5) of respondents using the transport system less than once a month and only one person using the service about once a week (1.4%). In contrast, 91.5% of respondents specified that they had not used the service before (n = 65). As reasons for non-usage, respondents stated *no need* (n = 33), *ignorance about the service* (n = 32), *predominant advantages of a private car* (n = 3) and *unclear functionality* (n = 2) as well as *costs* (n = 1) and *constraints of the operation time* (n = 1).

Social norms were assessed with the help of three items. For the first item concerning the image of MODS a significant effect of *time* was shown. Both groups showed an improvement in the assessment of the image of MODS from T1 to T2 ($F(1,67) = 6.130$, $p = .016$, partial $\eta^2 = 0.084$, $d = 0.3$). At T2, the friends' appraisal of the *Rufbus* (*I believe my friends would encourage me to use the Rufbus more often*) was more favourable than at T1 ($F(1,66) = 7.313$, $p = .009$, partial $\eta^2 = 0.100$, $d = 0.33$). The beneficial effect of the interventions was not found for the item concerning the family's appraisal of the *Rufbus* (*I believe my family would encourage me to use the Rufbus more often*, $F(1,67) = 0.075$, $p = .785$, partial $\eta^2 = 0.001$, $d = 0.03$). The analysis revealed no effect of the learning medium on the three items concerning social norms.

3.2. Knowledge stage

3.2.1. Awareness-knowledge

The pretest revealed that more than half of the study's participants had not heard about the local demand-responsive transport service before (57.7%, n = 41), showing that the pupils' awareness for the transport

Fig. 5. Experimental setting of the evaluation study.

service was rather low. After the intervention, all of the participants stated to have heard about the service.

3.2.2. Principles knowledge

For the assessment of the principles knowledge as a construct to measure the understanding of subjacent processes and background information an open question was analyzed: *Which are the differences between fixed-scheduled bus transport and demand-responsive bus transport*? The number of named correct differences (e.g. operates without fixed schedule, requires additional fee) was analyzed as a measure for the principles knowledge.

An ANOVA with repeated measurements showed a significant main effect of the factor *time* regarding the principles knowledge ($F(2,78) = 11.025$, $p < .001$, partial $\eta^2 = 0.260$, $d = 0.593$). Post-hoc tests revealed that the respondents' principles knowledge significantly increased between T1 ($M_{T1} = 0.96$, $SD_{T1} = 1.006$) and T2 ($M_{T2} = 1.85$, $SD_{T2} = 1.129$, $t(70) = -6.221$, $p < .001$, $d = 0.597$) and between T2 and T3 ($M_{T3} = 1.475$, $SD_{T3} = 0.877$, $t(39) = -2.876$, $p = .006$, $d = 0.418$) as shown in Fig. 6. Concerning the effect of the learning medium, the analysis revealed that in T2, the amount of the named differences did not significantly differ between the two experimental groups ($M_{T2\_serious\_game} = 1.95$, $SD_{T2\_serious\_game} = 1.25$; $M_{T2\_online\_research} = 1.74$, $SD_{T2\_online\_research} = 0.99$; $t(69) = 0.783$, $p = .436$). As shown in a *t*-test, the retention rate significantly differed between the two groups after four weeks in T3 ($t(39) = 2.098$, $p = .043$, $d = 0.32$) in a way that the group that had played the game retained more knowledge about the differences between the bus concepts ($M_{T2\_serious\_game} = 1.73$, $SD_{T2\_serious\_game} = 0.63$) than the control group ($M_{T2\_online\_research} = 1.17$, $SD_{T2\_online\_research} = 1.04$).

3.2.3. How-to-knowledge

Looking at the participants' knowledge about the functionality and the booking process of demand-responsive transport (*Which details do you know about the functionality of demand-responsive transport?*), the analysis revealed an effect of time but no effect of the learning medium. The number of named correct details (e.g. booked in advance) was analyzed as a measure for the how-to-knowledge.

An ANOVA with repeated measurements showed a significant main effect of the factor *time* regarding the principles knowledge ($F(2,78) = 22.112$, $p < .001$, partial $\eta^2 = 0.362$, $d = 0.753$). Post-hoc tests revealed that the how-to-knowledge significantly increased between T1 ($M_{T1} = 1.25$, $SD_{T1} = 1.431$) and T2 ($M_{T2} = 2.65$, $SD_{T2} = 1.435$, $t(70) = -6.613$, $p < .001$, $d = 0.617$) and between T2 and T3 ($M_{T3} = 2.00$, $SD_{T3} = 1.177$, $t(39) = -4.118$, $p < .001$, $d = 0.550$). The amount of the named characteristics of MODS slightly failed to reach significance when compared between the two experimental groups in T2 ($M_{T2\_serious\_game} = 2.35$, $SD_{T2\_serious\_game} = 1.46$; $M_{T2\_online\_research} = 2.97$, $S_{T2\_online\_research} = 1.36$; $t(69) = -1.847$, $p = .069$, $d = 0.22$). After four weeks (T3), the amount of characteristics decreased in both groups ($F(1,38) = 17.024$, $p < .001$, partial $\eta^2 = 0.309$, $d = 0.67$). No significant effect of the learning medium on the retention rate in T3 was shown in a *t*-test ($t(38) = -1.083$, $p = .286$) (Fig. 7).

The effects of an increase of knowledge about the concept of demand-responsive transport are in line with the subjective perception of the participants that assessed their knowledge about MODS (*How good is your knowledge about the functionality and the booking process of mobility on demand systems*?). An ANOVA with repeated measurements showed a significant main effect of the factor time regarding the self-assessed knowledge ($F(2,78) = 48.918$, $p < .001$, partial $\eta^2 = 0.556$, $d = 1.12$). Post-hoc tests revealed that the respondents' self-assessed knowledge significantly increased between T1 ($M_{T1} = 1.83$, $SD_{T1} = 1.23$) and T2 ($M_{T2} = 3.52$, $SD_{T2} = 0.984$, $t(70) = -11.403$, $p < .001$, $d = 0.806$) but no significant effect was found between T2 and T3 ($M_{T3} = 3.68$, $SD_{T3} = 0.859$, $t(39) = 0.408$, $p = .686$). In line with the results concerning the participants knowledge about the functionality of MODS that found a marginally significant difference in the amount of named facts between the two experimental groups, the control group assessed their knowledge better in T2 ($M_{T2\_online\_research} = 3.91$, $S_{T2\_online\_research} = 0.62$) than the experimental group ($M_{T2\_serious\_game} = 3.16$, $SD_{T2\_serious\_game} = 1.12$; $t(69) = -3.449$, $p = .001$, $d = 0.38$).

3.3. Stage of persuasion

3.3.1. Perceived usefulness

For the assessment of the Perceived Usefulness a new variable was computed that reflected the mean Perceived Usefulness over the five items. Internal consistence was acceptable as shown by a Cronbach's

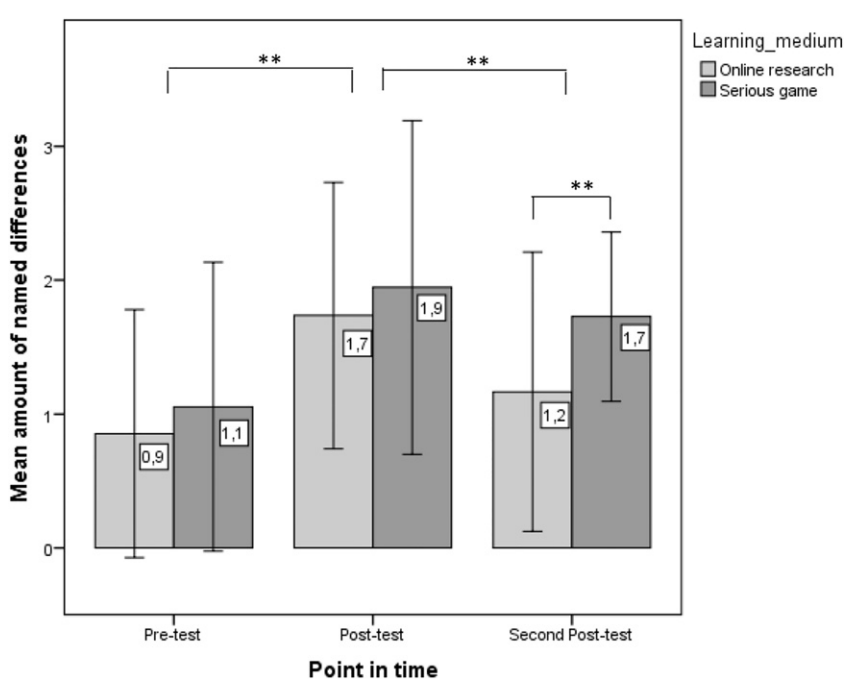

Fig. 6. Mean amount of named differences between bus concepts according to learning medium and time of measurement. Whiskers represent ±1 standard deviation. ** $p < .05$.

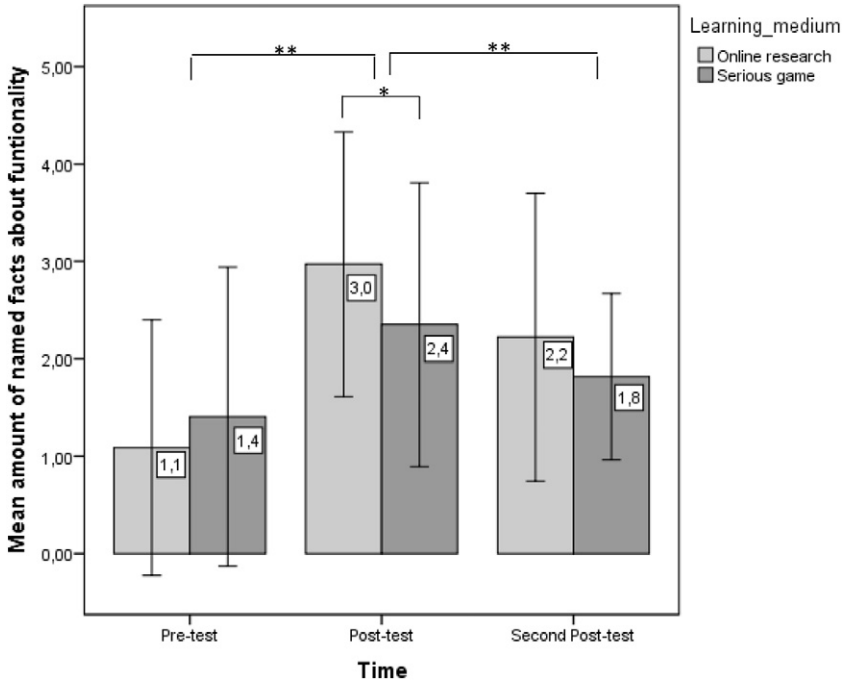

Fig. 7. Mean amount of named facts about the functionality and booking process of demand-responsive transport according to learning medium and time of measurement. Whiskers represent ±1 standard deviation. * $p < .1$, ** $p < .05$.

alpha of $\alpha = 0.64$. An ANOVA with repeated measurements showed a significant main effect of the factor *time* regarding the mean Perceived Usefulness ($F(2,72) = 7.636$, $p = .001$, partial $\eta^2 = 0.175$, $d = 0.461$). Post-hoc tests revealed that the mean Perceived Usefulness significantly increased between T1 ($M_{T1} = 2.85$, $SD_{T1} = 0.650$) and T2 ($M_{T2} = 3.06$, $SD_{T2} = 0.67$, $t(70) = -2.734$, $p = .008$, $d = 0.31$) and significantly decreased between T2 and T3 ($M_{T3} = 2.59$, $SD_{T2} = 0.65$, $t(36) = -4.007$, $p < .001$, $d = 0.555$) as shown in Fig. 8. The mean perceived usefulness was marginally higher in T3 for experimental group ($M = 2.75$, $SD = 0.66$) than for the control group ($M = 2.39$, $SD = 0.60$, $t(35) = 1.712$, $p = .096$, d = 0.278).

Looking at the usefulness items separately, significant effects of the learning medium revealed. More specifically, the Perceived Usefulness for transport agencies was assessed higher in T3 by participants that played the game ($M = 3.52$, $SD = 0.81$) than by participants that dealt with the online research ($M = 2.75$, $SD = 1.07$; $t_{T3}(35) = 2.509$

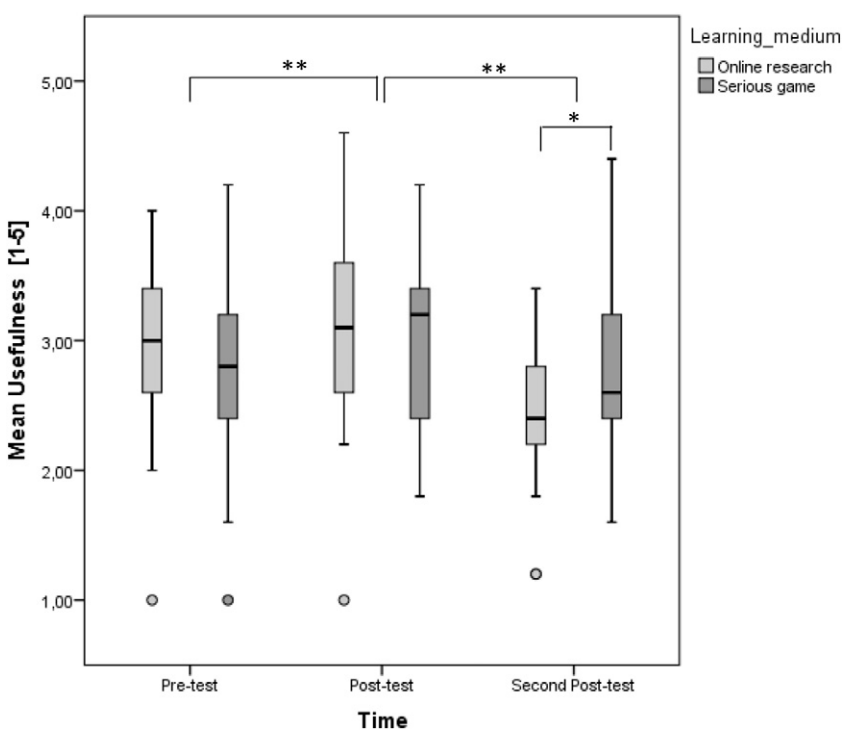

Fig. 8. Usefulness assessment according to learning medium and time of measurement. Whiskers represent 95% confidence interval. Note. * $p < .1$, ** $p < .05$.

$p = .017$, $d = 0.39$). Playing the game also was linked to a higher Perceived Usefulness concerning the improvement of respondents' personal mobility in T3 ($M = 2.19$, $SD = 1.33$) compared to the online research ($M = 1.44$, $SD = 0.63$; $t(35) = 2.092$, $p = .044$, $d = 0.33$). In T2 and T3, the control group assessed the benefits for the environment better ($M_{T2} = 3.47$, $SD_{T2} = 1.19$; $M_{T3} = 3.13$, $SD_{T3} = 1.15$) than the experimental group ($M_{T2} = 2.76$, $SD_{T2} = 1.09$; $M_{T3} = 2.48$, $SD_{T3} = 0.93$; $t_{T2}(69) = -2.642$, $p = .010$, $d = 0.30$; $t_{T3}(35) = -1.902$, $p = .065$, $d = 0.30$).

3.3.2. Perceived ease of use

In line with the process concerning the Perceived Usefulness, a new variable was computed, reflecting the mean value of the three Ease of Use items. Internal consistence of the construct was acceptable as shown by a Cronbach's alpha of $\alpha = 0.70$. An repeated measures ANOVA showed no significant effect of time regarding the mean perceived Ease of Use ($F(2,72) = 2.193$, $p = .119$, partial $\eta^2 = 0.057$). *t*-Tests revealed no effect of the learning medium on the mean Ease of Use in T2($t_{T2}(69) = 0.605$, $p = .547$) or T3 ($t_{T2}(35) = -1.188$, $p = .243$). Accordingly, further analysis revealed no significant effects of the time or the interaction of time and the learning medium regarding the separate items of the Ease of Use construct.

3.3.3. Attitude

The respondents' attitude towards MODS was measured and analyzed concerning the perceived reliability, price, speed and environmentally friendliness of MODS.

The analysis revealed no significant time effect in perceived *reliability* ($F(2,66) = 1.763$, $p = .180$, partial $\eta^2 = 0.051$), *price* ($F(2,66) = 0.126$, $p = .882$, partial $\eta^2 = 0.004$), *speed* ($F(2,70) = 1.483$, $p = .234$, partial $\eta^2 = 0.0041$) but for *environmentally friendliness* ($F(2,70) = 3.759$, $p = .028$, partial $\eta^2 = 0.097$, $d = 0.328$). A post-hoc analysis showed that the perceived environmentally friendliness of MODS marginal significantly increased between T1 ($M_{T1} = 2.85$, $SD_{T1} = 0.919$) and T2 ($M_{T2} = 3.0$, $SD_{T2} = 1.12$, $t(67) = -1.687$, $p = .096$, $d = 0.202$) and significant decreased in T3 ($M_{T3} = 2.68$, $SD_{T3} = 1.00$; $t(36) = -2.435$, $p = .020$, $d = 0.376$). The comparison of the learning medium revealed a significant effects on participants attitude concerning the assessment of it's environmentally friendliness. At T2, the control group assessed the environmentally friendliness of MODS significantly better ($M_{T2} = 3.44$, $SD_{T2} = 0.93$) than the experimental group ($M_{T2} = 2.60$, $SD_{T2} = 1.14$; $t(67) = -3.352$, $p = .001$, $d = 0.38$).

The participants' attitude towards MODS was also assessed with the help of a more qualitative open question: *Which three words come to your mind first, when you think about mobility on demand systems?* The associations were analyzed according to their valence. Three clusters were built according to the valence of the attributed terms: 1) *positive* (p.e. comfortable, punctual), *negative* (p.e. unreliable, awkward) and *neutral* (p.e. bus, transport). As shown in Fig. 9, the percentage of neutral attributions decreased in both groups between T1 and T2. For the control group, the share of neutral attributions was 79.6% in T1 and 59.8% in T2 as well as 69.1% and 54.5% for the experimental group respectively. In contrast, the number of positive as well as negative attributions concerning MODS increased between T1 and T2. Synoptically, after the intervention the participants' attitude concerning the service becomes more valent. This increase in valence of the appraisal happens in both directions – towards a more positive as well as a more negative appraisal. The most common negative attributions of the participants that have played the game in T2 were “intricate” (n = 3), “stressful” (n = 2) and “waiting” (n = 2), whereas most often named positive associations were “fast” (n = 11) and “flexible” (n = 8). In contrast, the control group mentioned “environmentally friendly” (n = 7) and “fast” (n = 6) as positive associations and “expensive” (n = 3) as negative associations concerning MODS.

3.4. Decision stage

Respondents' Behavioural Intention to use was measured with the help of two items:1) How likely is it that you will use the Rufbus within the next four weeks? and 2) I believe I will use the Rufbus within the next three months. An ANOVA with repeated measurements found a significant effect of time on the perceived likelihood to use the local MODS within the next four weeks in a way that the willingness increased after the intervention ($M_{T1} = 0.916$, $SD_{T1} = 1.763$, $M_{T2} = 1.43$, $SD_{T2} = 0.953$, $F(1,70) = 4.534$, $p = .037$, partial $\eta^2 = 0.061$, d = 0.477). No significant differences

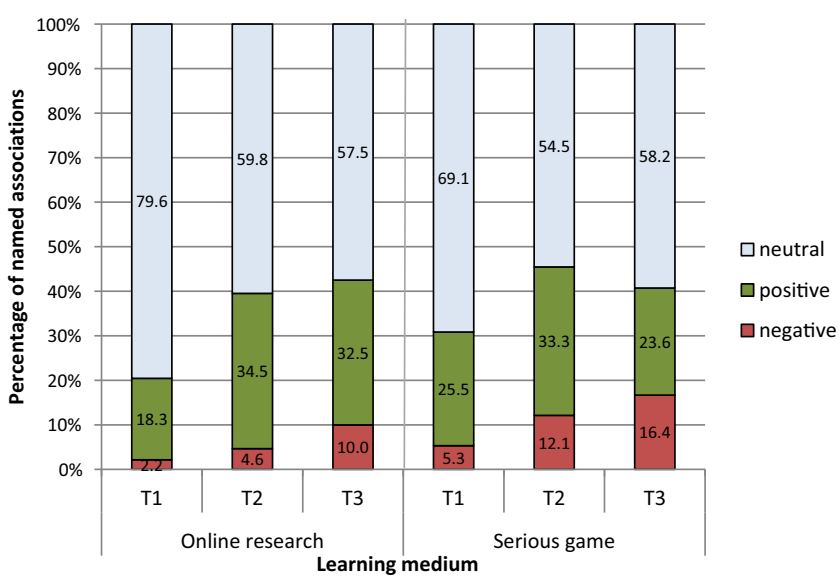

Fig. 9. Distribution of negative, positive and neutral assessed words according to time and learning medium. Note. negative: pointless, to wait, detours, money, expensive, unreasonable, unpunctual, stressful, crowded, environmental pollution, insufficient, infrequently available, complicated, unreliable, insecure; positive: spontaneous, cheap, flexible, convenient, economical, contemporary, environmentally friendly, punctual, comfortable, reliable, smart, reasonable, uncomplicated; neutral: to call, bus, transport, telephone, App, taxi, individual, small, bus driver, to pick sb. up, retired persons, elderly, to walk, to ride, seat, share, to book, booking, private, school, excursion, front door, reservation, road, mobile phone, hitchhiker, different, to plan, stop, on demand, Uber, traffic, alternative transport mode, car, mobility, independent, persons, unknown, at the weekend, route planning, public, village, organisation, Teltow-Fläming.

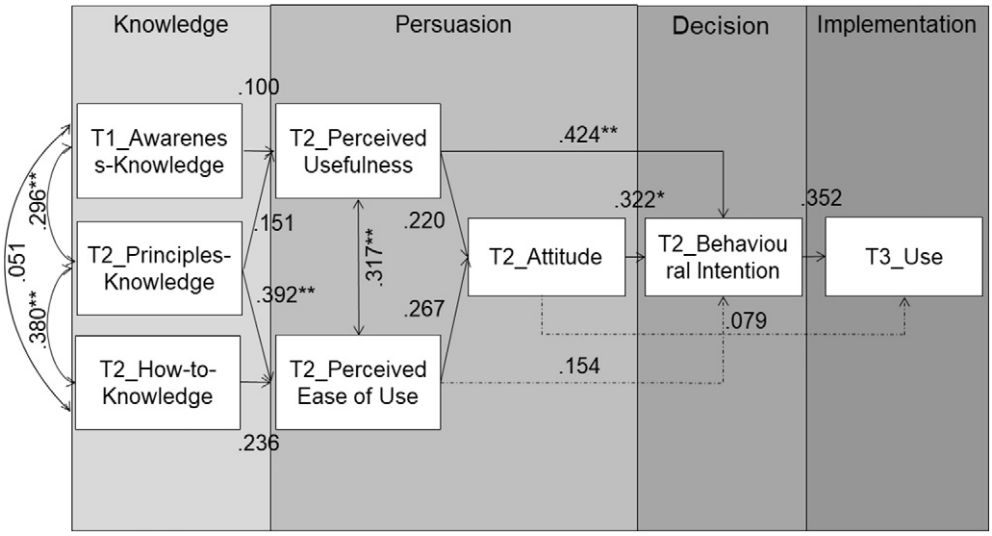

Fig. 10. Path model of the direct and indirect effect of the exogenous variables of the research model on the use behaviour in T3. Note. Awareness knowledge was measured before the intervention in T1.

were shown between T2 and T3 ($M_{T3} = 1.38$, $SD_{T3} = 0.953$, F(1,36) = 0.063, $p = .803$, partial $\eta^2 = 0.002$). No effect of the learning medium on the perceived likelihood of using MODS within the next four weeks was found directly after the intervention in T2 ($t(69) = -0.040$, $p = .968$), nor four weeks later ($t(35) = 1.065$, $p = .294$).

Concerning the concrete willingness to use the transport service within the next three months, no significant effect of the intervention revealed when comparing T1 and T2 ($F(1,68) = 0.330$, $p = .567$, partial $\eta^2 = 0.005$). No effect of the learning medium on the behavioural intention was found directly after the intervention in T2 ($t(69) = -0.812$, $p = .419$), nor four weeks later ($t(27) = -0.365$, $p = .718$).

3.5. Implementation stage

In T3, only one participant stated to have used the mobility on demand system in the past four weeks (1.4%). The person concerned had used the local MODS before and belonged to the experimental group. Due to the low usage number, no significant effect of the learning medium on the use behaviour was found ($t(37) = 0.876$, $p = .386$).

3.6. Path modeling

To describe the dependencies between the variables of the research model, a path analysis was conducted. Path analysis is special case of structural equation modeling based on a structural model that describes the casual influences of exogenous variables on endogenous variables (Golob, 2003). Fig. 10 presents the results of regression analysis for the experimental group and describes the relationship of the variables by the path coefficients (standardized beta coefficient). As shown here, the Percieved Usefulness after playing the game (T2) significantly predicted the Behavioural Intention to use MODS. As expected, the direct link between the *Perceived Ease of Use* and the *Behavioural Intention* was not significant. Neither was the direct releationship between *Attitude* and *Use* in T3. Yet, the effect of *Attitude* on *Behavioural Intention* was significant.

4. Discussion

4.1. Summary and interpretation of findings

The paper describes the application and empirical investigation of the serious game *B.u.S.* for introducing mobility on demand systems to prospective users. More specifically, the aim of the gamified approach was to raise awareness concerning the offered MODS and to counteract the lack of knowledge about the service concept as the main reason for not using mobility on demand service like *Kutsuplus* (Weckström et al., 2018). The game's effectiveness as a tool for addressing the challenges of conceptual comprehension, favourable appraisal and acceptance was assessed with the help of an experimental evaluation study in a high school. To conclude, the study found clear indications for beneficial effects of the gamified approach to address the challenge of sufficient conceptual comprehension and a positive appraisal but not for the acceptance challenge. In regards to the research model, the gamified approach proved conducive for supporting the first phases of the adoption process (knowledge and persuasion phase).

Both interventions, the online research as well as the serious game proved beneficial in enhancing participants' knowledge about the underlying principles of the mobility on demand service concept and to increase the participants how-to-knowledge concerning the functionality of the bus concept. Yet, the analysis of the post-hoc test four weeks after the intervention revealed that the group that had played the game retained more knowledge about the differences between the mobility on demand system and the fixed-scheduled bus, indicating higher principles knowledge. The study thus confirms the findings concerning the effectiveness of game-based learning as instructional method to support knowledge acquisition and concept understanding (Connolly et al., 2012; Randel et al., 1992; Sitzmann, 2011; Tennyson and Jorczak, 2008; Wouters et al., 2013) for the application in the transport sector. Contrary to the expectations, the online research proved more beneficial in supporting the knowledge acquisition concerning the how-to-knowledge. As shown, the pupils that searched online mentioned more details about the functionality of MODS and assessed their knowledge better than the ones that played the game. Apparently, online information-seeking was more suitable for providing detailed information. This finding should be reflected in the light of *Millennials* information acquisition habits that are mainly based on web-based platforms and services. A recent study revealed that adolescents most often use online search engines and social media for getting advice or how-to-information (Young, 2015). The common use of the internet as a source of information among adolescents might be an important explanation for the finding that the how-to-knowledge was higher among the participants that performed the online research.

The game proved also to be beneficial for addressing the second challenge of introducing new mobility systems to prospective users – the challenge of a favourable appraisal. The study revealed an increase in the participants' Perceived Usefulness of the mobility on demand system after playing the game, which proved to be an important determinant of a favourable appraisal of DRT systems (König and Grippenkoven, 2019a). As shown in the path model, the Perceived Usefulness affected the Behavioural Intention to use the local MODS. As intended in the game concept,

the players assessed the usefulness for the transport agencies higher than by participants that dealt with the online research. This effect might be traced back to the learning through role play that has shown to improve player's cognitive and emotional involvement (Colucci-Gray, 2004) and might facilitate the change of players' perspective. However, the assessment of the perceived usefulness decreased in both groups after four weeks. Playing the game also was linked to a higher perceived usefulness concerning the improvement of individual mobility in the post-test four weeks after the intervention. Interestingly, the control group of pupils that researched online assessed the benefits for the environment of MODS better than the pupils that have played the game. One possible explanation might be the game mechanics that required fast players' reactions. Due to the high number of rides and number of empty runs depending on the player's strategy, the service might be perceived as inefficient or little sustainable by the players. Another explanation is the environmentally-friendly framing of MODS at websites like "Dial-a-ride services are modern, flexible, environmentally-friendly and fast transport means […]" (Deutsche Bahn, 2019, translated from German).

The analysis of participants' free associations concerning MODS showed an increase in the valence of their appraisal ratings after the intervention in both groups. Interestingly, the valence increased in both directions after the intervention – participants' appraisal became either more positive or more negative. Apparently, dealing with the mobility concept intensified their opinion with regard to MODS. No significant differences were found concerning the attitude between participants that played the game and participants that performed the online research. The findings are in line with the results of a literature review by Soekarjo and van Oostendorp (2015), who found empirical research about the effectiveness of persuasive games on change of attitude to be still sparse. Thus, it cannot be concluded that playing a game leads to a greater change in attitude than experiencing a conventional medium of information acquisition like online research.

With respect to the phase of decision, the evaluation study revealed an increase in the willingness to use MODS for both groups after the intervention. Yet, the analysis showed no differences between the two groups indicating that playing the game did not enhance usage intention more strongly than the online research as has been expected. It must be noted that after the intervention, participants of both groups assessed the probability of using the local MODS within the next four weeks as very low ($M = 1.44$, $SD = 0.92$). Hence, the missing link between playing the game and an increased willingness to use MODS might be traced back to a floor effect as all of the responses are clumped at the lower end of the scale. Another possible explanation is the intended perspective change that was facilitated by the role game. Yet, to emphasize with the character's role might have impeded the pupils' feeling of being addressed and personal consternation.

A possible floor effect might as well represent an explanation for the missing effect of the serious game on the actual use of the local mobility on demand system four weeks after the intervention. Only one participant stated to have used the MODS during the period concerned. Yet, a considerable number of further studies failed in revealing a positive effect of serious games on actual behaviour. A meta-analysis by DeSmet et al. (2014) found that the majority of the quantitative validation studies produced heterogeneous results and only few showed small overall effects of serious games on healthy lifestyle behaviour. As reasons for not having used the MODS, the respondents primary answered "no need" and more specifically "I prefer riding bike". They mentioned also "costs", "long wait times" and "environmental concerns" as reasons for not using the service. The named reasons thus underline the importance of prior conditions such as needs for behavioural changes. However parents that drive their children to hobbies represent a relevant share of the traffic volume in Germany (Nobis and Kuhnimhof, 2018). Offering an alternative for those accompanying trips could be an interesting field for the beneficial use of MODS.

4.2. Limitations and further research needs

Within the development process and the application of the serious game *B.u.S.* the researchers faced several challenges that are reported in detail in Freese et al. (2019, in preparation). In the following, challenges faced in the application of the serious game as tool for the introduction of mobility on demand services will be reflected.

First, it has to be considered that the chosen evaluation approach affects the outcomes of the evaluation studies. The selection of an appropriate task for the control group was an important prerequisite for the study design since it should be ecological valid on the one hand as well as comparable to the gaming task of the experimental group on the other hand. The online research task was chosen since the majority on teens use the internet for information-seeking (Micheli, 2015). Yet, it was hard to control for what information the pupils of the control groups searched for. Another limitation of the study design was that the game was played only once and only for 15 min as this was the average time needed to finish the sixth level. According to the procedural rhetoric framework of *B.u.S.*, 15 min were enough to provide the relevant information the game aimed to impart. Furthermore, studies suggest that pupils' attention span last about 10 to 15 min (Benjamin, 2002) even though a wide-ranging debate on the topic has opened up (Wilson and Korn, 2007). A longer game play would have not necessarily mean a better knowledge acquisition as studies found that longer play duration revealed only minor improvements or no effects on the knowledge improvement of players (Dunbar et al., 2013; Veinott et al., 2013). Yet, the study by Veinott et al. (2013) indicated that repeated game sessions facilitate good learning improvements. Thus, a starting point for further research could be an extended study design that uses repeated game sessions. Adding on this, numerous empirical studies proved that behavioural changes towards more sustainable mode choices take time as routines and habits are persistent (Chen and Chao, 2011). Thus, long term studies are necessary to evaluate actual transformation effects of gamified approaches.

Furthermore, the authors like to emphasize that the findings of the study are restricted to the specific study context. Due to the study design and the selection of the participants, the transferability to other settings is limited. It should be considered that the pupils' participation in the experiment was to some kind mandatory as the study was conducted during a regular school class. It can be assumed, that the results might differ from other groups of participants if they participate during their leisure time or are older and thus less digital-native.

For interpretation of the findings it should be considered that the data was collected with the help of questionnaires before, after and four weeks after the experiment. Since the study's aim was to assess the effect of the game on the knowledge, attitude and willingness to use mobility on demand systems, subjective data collection measures represent a valid instrument. Even though the survey-based data collection as a quantitative measure is a widespread instrument in psychological and sociological research (Rossi et al., 2013) as well as serious game research (Smith et al., 2015), using questionnaires is often accompanied by challenges concerning unintended response effects and measurement errors (Rossi et al., 2013). Thus, in planning and conducting the questionnaire study the guidelines of the American Psychological Association were regarded (Cooper et al., 2012).

A further shortcoming of the study design is the fact that no in-game metrics were collected like the achieved goals, the times spend on each level and obstacles occurred in playing the game. Yet, this data could have contributed to reflecting the findings from the survey and provide insights into individual's game performance. Accordingly, applying a mixed methods approach for data gathering in the serious game context was proposed by Mayer et al. (2014).

Furthermore, for the interpretation of the results it has to be considered that the intended learning results highly depend on the game mechanics and properties of the serious game (Ritterfeld et al., 2009). In a literature review, Connolly et al. (2012) found a sizeable proportion of papers reporting unintended outcomes of playing. As an example, the presented study found a negative effect of the serious game on the perceived environmentally friendliness of MODS compared to the control group. A recommended improvement of *B.u.S.* would therefore lie in the supplement of a private car for a comparison of the environmentally sustainability of

different transport modes. That way, the environmentally benefits of MODS compared to the use of private cars could be visualized. Further studies could also address the topic of individual concerns and the feeling of affectedness by the topicto facilitate the willingness for behavioural changes. Adding further characters and roles to the game, especially a first-person character might support the feeling of being addressed and facilitates the transfer of the gained knowledge and awareness to the daily life of the players.

Based on the evaluation study several improvements for the serious game could be derived, like adding a private car as another reference besides a fixed-scheduled bus to the game. Furthermore, adding a user perspective by a first-person character to *B.u.S.* is recommended to demonstrate the beneficial effects (e.g. short waiting times) as well as the trade-offs (e.g. detours caused by fellow travelers). To conclude, the authors recommend an iterative design and development process of games for research that allows for the adaptation of game mechanics according to the findings of early evaluation studies. Furthermore, other research models could be applied to assess the user needs and factors contributing to user acceptance that go deeper into the human needs by taking further determinants of human behavior such as self-determination, fears or relatedness into account (Dreßler et al., 2019).

4.3. Recommendations for the application of serious games for facilitating knowledge acquisition and adoption

Based on the experiences made in developing and applying *B.u.S.* several recommendations can be derived that might support further research activities that aim to use gamified approaches for facilitating the adoption of new technology or services. First of all, it should be emphasized that the use of gamified approaches requires the researchers control over the mechanics and the application of the game. According to Donchin (1995): “A game is useful as a research tool if, and only if, the investigator can exercise systematic control over the game's parameters” (Donchin, 1995, p. 218). Thus, writing an own game is highly recommended to have full control over the game and its effects on players. Accordingly, as mentioned before, goals and aims of the serious game should guide the process of game design and development. Thus, game mechanics should be adapted to the objectives and purpose of the game as unintended outcomes are otherwise not uncommon (Connolly et al., 2012). Yet, it is not recommended to design a serious game that meets all objectives at once but to create different games for different purposes like to facilitate knowledge acquisition, to raise awareness or to prompt behavioural change. In line with previous research, our study suggests that serious games for persuasion and behavioural change should enable self-directed discovery (Ferrara, 2013).

Researchers should also prove whether their research objective requires a serious game or whether gamification approaches might be more appropriate to affect behaviour in incentivizing behavioural changes in routines and habits since gamification is integrated into the daily life of the person (Kazhamiakin et al., 2015; Liyanage et al., 2019; Sailer et al., 2017). Defining the core message of the research is a promising approach to decide for the appropriate tool and design it around the clear core aim (Ferrara, 2013).

When designing and applying games for learning purposes the narrow line between too few abstraction of the complex reality and too much simplification should be considered. As Michael and Chen (2006) state: “The simplification and definite rules of simulation models are one of their greatest strengths, but they are also the potential source of the greatest weaknesses” (Michael and Chen, 2006, p. 33). Ferrara (2013) state that persuasive games should be tied to the real world in order to be credible. On the one hand, an abstraction and simplification of the real world is needed for ensuring an actual game play. Thus, a comprehensive analysis of the game's objectives is needed to define where exactly a high degree of realism and complexity is needed and where a higher degree of abstraction is useful. This simplification must be met by a comprehensive debriefing and reflection phase to ensure the transfer of the learned to the real world. The use of a written debriefing or a reflection of the just experienced content is highly recommended for any application of serious games. Beyond that, the importance of fun to get players to play the game should not be forgotten. As Cooper et al. (2010) state: “We can take lessons from traditional game design to do this: rewarding players and keeping them interested are necessary for any game” (Cooper et al., 2010, p. 47).

Giving regard to the growing demands for citizens' participation and public engagement in transportation planning (Quick, 2014), serious games might be an interesting method to involve citizens in the process. By doing so, serious game might contribute to obtain public legitimacy and co-create a plan that satisfies the mobility needs of people as requested in the Sustainable Urban Mobility Plan (Langweg et al., 2014). The *City of Helsinki's Participation Game* is one recent example for the gamified involvement of citizens and co-creation with residents in the operations and services of the city (City of Helsinki, 2019). The presented game proved to be an efficient instrument for facilitating knowledge acquisition and improve players' attitude. Giving regard to the benefits of the game, the authors plan to use *B.u.S.* for participatory processes in the context of sustainable transport planning.

5. Conclusions

The paper presented a digital learning game, a so called *serious game*, to introduce mobility on demand concepts to prospective users since missing knowledge about the operation concept and lack of understanding are essential usage barriers. The ability of the serious game to enhance players' knowledge and conceptual understanding, to improve the appraisal of the mobility system and to strengthen the willingness to use was tested in an evaluation study. The comparison with a control group, performing an online research on the topic, showed that players' principles knowledge and perceived usefulness of the mobility service increased more strongly. Dealing with the topic improved participants' willingness to use the service independently of the intervention. It was shown that the Perceived Usefulness was a powerful predictor of the Behavioural Intention to use the service. To conclude, the study found strong evidence for beneficial effects of the gamified approach to address the challenge of sufficient conceptual comprehension by enhancing the awareness and principles knowledge of the players. The gamified approach of *B.u.S.* emerged as a tool that is not less effective for facilitating the adoption of MODS than a conventional online research but proved to be more beneficial than the online research in terms of knowledge long-term retention and a higher perceived usefulness concerning MODS.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of competing interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trip.2019.100079.

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