SERIOUS GAMES: A PLAYFUL APPROACH TO REDUCE USAGE BARRIERS OF INNOVATIVE PUBLIC TRANSPORT SYSTEMS

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Around the world, new sustainable mobility solutions and intelligent transport systems emerge. However, those mobility services are often inadequately introduced to the prospective users. An insufficient provision of information about how to use the new mobility service or the absence of a transparent and comprehensible information environment could create usage barriers that might cause a refusal of the mobility service. To improve users' conceptual understanding of a new demand-responsive transport system the serious game *B.u.S.* is developed by the authors. The objective behind the serious game is to provide information about the operating concept of a demand-responsive bus in a playful way. To enhance knowledge about the new bus system players are put in the position of a public traffic planner. Players have the mission to plan and operate a bus system that satisfies customer needs on the one hand and meets the goal of an efficient and environmental friendly operation on the other hand. It is hypothesized that the serious game improves the conceptual understanding of the mobility service. Accordingly the game is supposed to improve the players' attitude towards the new transport service and as a consequence increases the intention to use the new bus system.

1. INTRODUCING NEW PUBLIC TRANSPORT SYSTEMS

1.1 Demand-responsive public transport

These days, automation, digitalization and mobile applications are the driving forces behind the development of innovations in transportation. In order to achieve the goal to reduce motorized private transport, public transport should offer flexible and personalized mobility services. Reduced walking and waiting times by offering door-to-door services can be used as improvements to compete against private car public transport, as well as direct connections and fewer transfers (Häme, 2016). The growing popularity of new mobility services that are based on reservation and partly payment via mobile devices, as for example *Car2Go* (carsharing), *Uber* (ride sharing) or *BlaBlaCar* (carpooling), underlines the relevance of new and flexible demand-oriented mobility services. Over the last years, several so called mobility-on-demand services started to operate in urban areas like *Kutsuplus* in Helsinki (Rissanen, 2016) or *CleverShuttle* in Leipzig (GHT Mobility GmbH, 2016). Those systems services provide flexible and customizable service by operating exclusively according to the actual demand. In contrast to taxi services, these mobility solutions are based on pooling of ride requests and shared rides. To further increase traffic flow and flexibility of service, especially in terms of service hours, recent studies and pilot projects address the potential of driverless shuttles (Pavone, 2015; Beiker, 2015; ITF, 2016).

Nevertheless, the concept of mobility on-demand is not new. Since several decades, traffic planners employ demand-responsive transport (DRT) systems in areas of low and disperse demand (Ambrosino, Mageean, Nelson & Romanazzo, 2003; Mehlert, 2001). DRT is 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, Nelson and Wright, 2004; p. 324). The service concept of DRT allows to book rides at the desired departure time, origin and destination within a predefined operation area and time. Due to waiving fixed schedules and bus stops, DRT systems are a promising way for improving rural as well as urban public transport towards a more user-centered and at the same time cost effective mobility service (Mulley & Nelson, 2009; Velaga, Nelson, Wright & Farrington, 2012). Still, it is noticeable that most of the DRT systems in operation fail to reach a critical customer demand density and thus result in an occupancy rate comparable to private transport (König & Grippenkoven, 2017; Küpper, 2011) and high subsidy levels (Mageen & Nelson, 2003). Thus, the careful introduction to prospective users based on a previous analysis of facilitating factors and usage barriers is a crucial point to increase the users’ acceptance and the willingness to use DRT systems (Finn, Ferrari & Sassoli, 2004; Nelson & Phonphitakchai, 2012).

1.2 The project *Reallabor Schorndorf*

The project *Reallabor Schorndorf* addresses the goal to develop, operate and conduct research on a demand-responsive transport system at the city of Schorndorf (39.000 residents) in the south-west of Germany. The project started in February 2016, has a duration of three years and is funded by the Ministry of Science, Research and Art of Baden-Württemberg. The project bases on the *Reality-* or *Living lab* approach to design a bus system that operates in accordance to actual travelers’ needs and thus achieves a high level of public acceptance. Living Labs are an innovation environment in real-life settings in which services or products are created based on a comprehensive co-creation process with the prospective users (Bergvall-Kareborn & Stahlbrost, 2009). Within the project Reallabor Schorndorf the relevant stakeholders like the citizens of Schorndorf, the municipality and local companies are involved during the entire project term to create a bus concept that meets their requirements to a high degree.

1.3 Challenges in introducing a new public transport system

It is assumed, that having designed a flexible bus system that meets the users’ requirements to a high degree is a necessary, but not a sufficient precondition to achieve a high users’ acceptance and willingness to use the system. According to Rogers’ (1995) Innovation-Decision-Process, the first two steps of technology adoption that are preceding the actual motivation to use an innovative system are *knowledge acquisition* and *persuasion*. Thus, the project Reallabor Schorndorf is expected to face three major challenges when introduced to the users:

1. First, a challenge of *sufficient comprehension*,
2. Second, a challenge of *positive appraisal* and
3. Third, a challenge of *acceptance*.

The challenge of comprehension implies especially the users' understanding of the new transportation concept and how to use the bus system. Finn, Ferrari & Sassoli (2003) identified the awareness and the ease-of-use for customers as critical factors for the successful introduction of DRT systems. Thus, new mobility systems should be introduced to the prospective users in a comprehensive manner to reduce feelings of uncertainty and support the formation of a mental model of the system.

As the intention to perform a behaviour in question can primarily be predicted from a positive attitude towards the behaviour (Ajzen, 1991), the next step after comprehension is to achieve a favourable appraisal of the new bus system within individuals and the community. As König, Grippenkoven & Jipp (in press) show, the perceived usefulness of a transportation system forms an important part of the positive appraisal of DRT systems. To achieve a positive attitude towards the new bus system it seems thus necessary to increase its perceived usefulness by underlining the individual, societal and environmental benefit of the new concept.

A favourable appreciation of the new bus concept is a necessary but not a sufficient precondition for the adoption of a new system (Dethloff, 2004). To go beyond pure tolerance or tacit consent an active willingness to use the system is necessary for the adoption of a system. The combination of positive appraisal and active willingness to use is defined as *acceptance* according to Dethloff (2004, figure 1). In the context of DRT, the challenge of acceptance was addressed by Ambrosino, Nelson & Romanazzo (2003). Thus, it is a necessary step to encourage people to try out and to actively deal with the DRT.

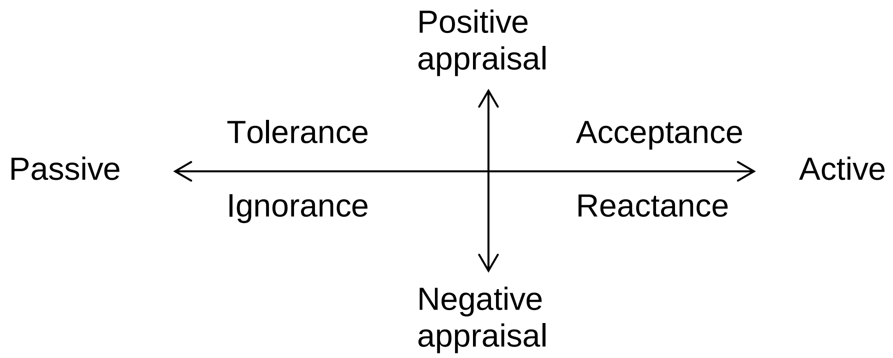

Figure 1: Definition of acceptance by level of appraisal and degree of activity, adapted from Dethloff (2004, p. 19)

To master the previously named challenges of comprehension, attitude and acceptance that come along the introduction of a new transport system, an interactive digital approach based on serious gaming appears to be a promising way. 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). Serious gaming has been proven to enhance learning and knowledge acquisition (Wouters et al., 2013; Breuer & Bente, 2014), to improve attitude in different contexts (Connolly at al., 2012) and to prompt behavioural change (Klimmt, 2009). With the help of a serious game, prospective users of the DRT can explore and try out the new bus concept in a playful way within a protected space before the actual start of operation.

1.4 Game-based learning

Effective learning environments are mainly based on the same features as games - they are motivating, provide continuous feedback, maintain the learners/players attention and provide an appropriate level of challenge (Shute, 2011). That is the reason why play and game were applied for learning purposes since thousands of years (Baykal, 2013). Game-based learning is premised on an environment in which learning works through an experiential rather than an instructional approach (De Freitas & Neumann, 2010). Based on Kolb's (1984) Experiential Learning Cycle, De Freitas & Neumann (2010) proposed the Exploratory Learning Model that describes the process of experiental learning as a cyclical process of five steps: gaining concrete experiences, exploring the environment, reflecting about the experience, forming abstract concepts and testing in new situations (figure 2). The theory underlines the importance of exploration as a key learning construct that empowers learners to interact with the environment, observe and actively acquire knowledge.

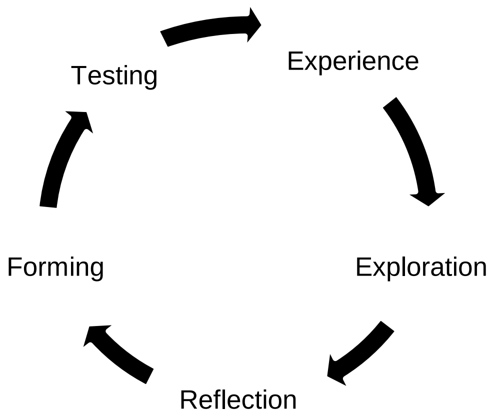

Figure 2: Exploratory Learning Model adapted from De Freitas & Neumann (2010)

Literature outlines several important aspects to be considered for creating a game for learning. First, motivation is a key aspect of effective learning and needs to be maintained through feedback in the reflection phase and active player's engagement during the whole learning cycle (Garris, Ahlers, & Driskell, 2002). Therefore, a key challenge for game designers is to get the correct balance between delightful play and fulfilling specified learning outcomes. Konijn & Bijvank (2009) found that games may influence players' real-world knowledge the more they perceive realism in the game. In this context, the role of an effective debriefing is emphasized as post-game information allow players to draw parallels between game and real world and to transfer the learning patterns to their daily life (Crookall, 2010; Garris, Ahlers, & Driskell, 2002).

Well-designed serious games encourage players to interact with the game world, experience mechanisms and concepts and thus become instrumental tools that can support knowledge acquisition, help to change attitudes and encourage long-term change (Bogost, 2010).

2. THE GAMING APPROACH IN TRANSPORTATION RESEARCH

Transportation science is an exact science, based on empirical studies and traditional modelling approaches that aim to ensure safety of passengers and goods. Integrating the user's behaviour into transportation modelling has long been restricted to simulations. Driving or flight simulators rely on virtual reality techniques to attain a degree of reality as high as possible (Rossetti, Almeida, Kokkinogenis & Goncaves, 2013). As human decision making in the context of transport mode choice and traffic behaviour is not yet adequately simulated by artificial intelligence, gaming is a promising way to integrate the human factor into the complex socio-technical system of transportation (Mayer, Bekebrede, Van Bilsen & Zhou, 2009). In contrast to simulations, games do not propose to represent reality but are based on game dimensions like fantasy and challenge (Garris, Ahlers & Driskell, 2002).

During the last decade, games and game elements have captured the attention of professionals in the domain of transportation as well. In the transportation domain, several serious games have been developed and used to analyze, understand and change decision making and behavior of passengers, drivers, traffic planners or decisions-makers. For example, the project INSINC tried to manage peak demand in Singapore by incentivizing commuters to travel off-peak based on the gamification approach that uses game design elements in non-game contexts (Pluntke & Prabhakar, 2013). Kelpin, Giesel and Heinrichs (2016) used a gamification approach based on a mobility app successfully to convince people to use “greener” modes of transport, like bicycles. Gabrielli et al. (2013) used the *Eco-Dealer* game to promote awareness towards sustainable transport systems. Hauge et al. (2015) created a game, called *Protoworld*, to model and plan urban mobility. In the field of rail transport, *SprintCity* was created with goal to understand and train new forms of coordination, planning and decision-making in the context of transit-oriented development on rail corridors (Duffhues, Mayer, Nefs & van der Vliet, 2014). Thomas, Grippenkoven & Michaelsen (2017) describe a serious game to analyze the situation awareness of train operators. In the domain of air traffic, the game environment *D-Cite* was used by Schier, Freese & Mühlhausen (2016) to analyze cooperation and decision making in airport management.

3. THE SERIOUS GAME B.U.S.

3.1 Aim of the game

A serious game is developed by the authors to improve users' conceptual understanding of the new demand responsive transport system in Schorndorf and to increase users' acceptance. The objective behind the serious game B.u.S ("**B**ürger **u**nterrichten durch **S**piele" / engl.: "teaching citizens with games") is diverse. The above mentioned challenges of system introduction are aimed to be overcome by the game. First, the game aims to support knowledge acquisition and comprehension by providing information about the operating concept of DRT in comparison to regular, fixed-schedule busses. Second, affective learning outcomes and a positive appraisal are intended by conveying the system's benefits to the user and thus improving perceived usefulness of the new bus concept. The third goal of the game is to motivate the players to actively explore and experience the new bus concept in a protected space before the start of real operation in order to increase acceptance. Furthermore, the game aims to broaden the player's self-centered view on the transportation system by providing an insight into the effects of traffic planning for transport companies and society.

3.2 Game Concept

The mobile game B.U.S. puts the players in the position of a public traffic planner. Players follow the mission to plan and operate a bus system that satisfies the mobility needs of different residents on the one hand and meets the goal of an efficient and environmental friendly operation on the other hand. The game concept of B.u.S. is based on a puzzle game that challenges the players to solve missions, so called puzzles (Bates, 2004). Each level provides new and increasingly difficult mission goals as well as a growing number of options and resources. The puzzles are created in a way that the required competency is slightly above the learner's current competency. Thereby a condition of intrinsic interest and immersion, called *flow* is attempted to be achieved (Csíkszentmihályi, 1988). The missions can only be accomplished by using specific skills and knowledge that are collected through stepwise exploration, thus forcing the player to explore the game situation. The players can choose between a fixed-scheduled bus service and a demand-responsive bus service. Doing so, the game empowers the players to understand the logic of operational planning and become aware of the effects of traffic planning. The level-based role game of B.u.S. supports the acquisition of knowledge and comprehension of the new bus concepts, addressing the first aim of the game. Learning through role play was applied for different learning purposes and has shown to improve player`s cognitive and emotional involvement (Colucci-Gray, 2004). Furthermore, role play reinforces reflection about complex issues and a represents a medium of experiential learning (McSharry & Jones, 2000).

The game concept of B.u.S. is based on the conceptual framework for serious games of Yusoff, Crowder, Gilbert and Wills (2009) that aims to unite elements of pedagogy and gaming theory. Figure 2 shows the framework adapted to the game B.u.S. For specifying the learning activity the

Experiential Learning Model of De Freitas & Neumann (2010) was added to the framework. The player first experiences and explores the virtual city of Schorndorf, the residents' mobility demands and the transportation company`s resources. The explorative game approach empowers the player to develop concepts and strategies and reflect about possible outcomes. At each level, the player is confronted with a challenge that can only be solved through goal-directed exploration of the simulated system. With the help of the newly acquired knowledge the player forms a solution to fulfill the current mission. The phase of forming is followed by the testing phase in which the effects of the player's choice are immediately simulated. An evaluation-screen provides feedback about how successful the player's solution was in terms of passenger`s satisfaction, operational costs, emissions and effects on society´s contentment. A favourable appraisal of the new bus system, which addressed the second goal of B.u.S., is expected to be elicited by demonstrating the positive effects and benefits of a demand-responsive bus service for the passengers, the transport company, the society and the environment. The experiental 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 will be part of the gaming experience (Crookall, 2010).

For reaching the above named goals of the serious game it is crucial that the game concept is supported by a sophisticated user experience design to achieve a well-adjusted balance between effective learning and delightful play.

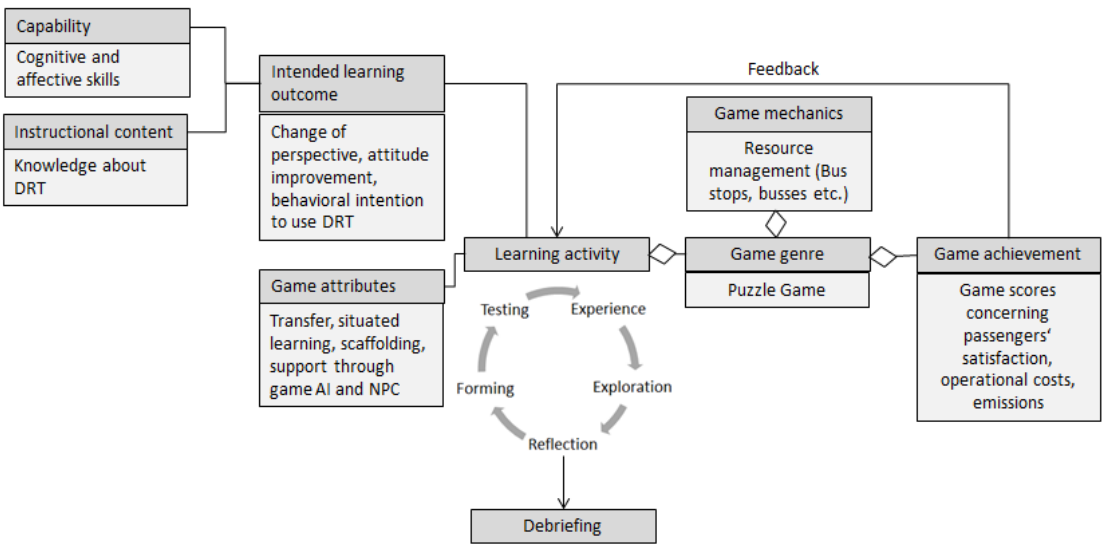

Figure 3: Serious Game framework of B.u.S. based on the Framework for Serious Games by Yusoff (2009) and the Exploratory Learning Model by De Freitas & Neumann (2010), DRT = Demand-responsive Transport, game AI = game Artificial Intelligence, NPC = Non Player Character

3.3 User Experience Design

User Experience (UX) goes beyond Usability as it describes the emotional and aesthetical experience apart from functional aspects as well (Richter & Flückiger, 2016). Thüring & Mahlke (2007) argue for a broader perspective on UX based on three basic elements: 1) The perception of instrumental qualities, 2) the perception of non-instrumental qualities and 3) the user's emotional responses. Based on their definition of UX, Thüring & Mahlek (2007) propose the CUE-model (Components of User Experience, figure 4). The CUE-model was applied to the game B.u.S. in order to reach a good players' appraisal of the game.

Instrumental qualities are closely related to the effectiveness and controllability of an interaction. The game B.u.S. attempts to achieve a good level of instrumental qualities with the help of a game artificial intelligence (game AI). The game AI uses internal analytics to collect data on the player`s performance. These data are used to adapt the game's difficulty to the varying level of player`s skills in a way that the required competency is slightly above the learner's current skills (Nareyek, 2004; Shute, 2011). In the case of an incongruence of player's skills and mission's challenge the game AI either increases the challenge`s difficulty or provides additional information and support to the player. Thus, an adequate level of challenge is obtained that is supposed to contribute to a sound User Experience. With the help of non-player characters (NPC; Nareyek, 2004), the game offers tips and practical advice on how to solve the current challenge as shown in figure 5. Adaptive advice has proven to support the knowledge acquisition of players (Leutner, 1993). Since this effect can be reinforced by the provision of background information on system variables (Leutner, 1993), the game B.u.S. gives detailed information about the effects of traffic planning and mobility behaviour on the society and the environment in an additional information tab. The use of NPC and background information is supposed to enhance the controllability and effectiveness of the game, thus increasing the instrumental qualities of B.u.S..

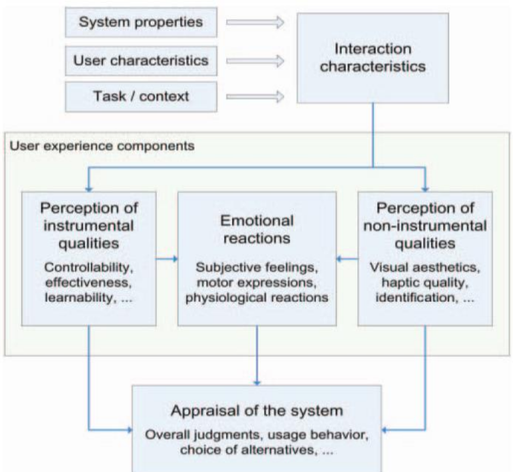

Figure 4: CUE-Model of User Experience (Thüring & Mahlke, 2007, p. 262)

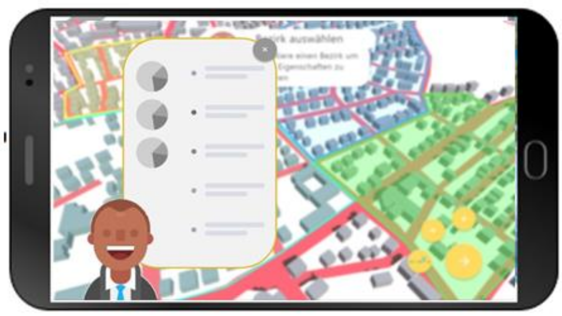

Figure 5: Schematic representation of the serious game B.U.S.

A favourable perception of *non-instrumental qualities*, the second UX component, results from the game`s appeal and attractiveness (Thüring & Mahlke, 2007). Within B.u.S. this UX component is facilitated by applying the design guidelines according to the principles of game design by Bates (2004). Furthermore, the MDA framework (standing for Mechanics, Dynamics and Aesthetics) is applied to B.u.S. (Hunicke, LeBlanc & Zubek, 2004). As shown in figure 6, the game component of *Aesthetics* is particularly important for UX design, because the player perceives the game dynamics and game mechanics through the lens of *Aesthetics.* Within B.u.S. this UX component is facilitated by interplay of the Aesthetics components Narrative, Discovery and Challenge that are describes in detail by Hunicke, LeBlanc & Zubek (2004).

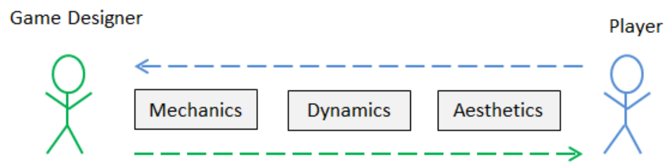

Figure 6: Game designers and players perspective on the game as described by the MDA Framework of Hunicke, LeBlanc & Zubek (2004)

The third UX component, *emotional reactions*, is facilitated by the help of the game AI as well. The game AI aims to attain the condition of flow that describes the experience of involvement, intrinsic interest and immersion (Csíkszentmihályi, 1988). Thus, achieving a condition of flow should be an important goal for game designers to reach a satisfying user experience, especially concerning the facet of emotional reactions. To facilitate emotional involvement the game makes use of *Personae* that characterize user groups (Mayas, Hörold & Krömker, 2012). By giving a face to the NPC the game aims to increase the player`s identification with the game characters that represent groups of Schorndorf`s residents, like school pupils, mobility impaired or elderly. By using those *Personae* the effects of player`s decisions in traffic planning on the society are made lively which is meant to increase player`s emotional involvement and thus enhances the overall appraisal of B.u.S..

3.4 Game Application and outlook

"*Videogames are an expressive medium. They represent how real and imagined systems work. They invite players to interact with those systems and form judgements about them.“ (*Bogost, 2010, p. VII)

As Bogost (2010) demonstrates, games are convincing tools that can be used for research and education in a variety of contexts. The game B.u.S. that was introduced in the article is designed to facilitate the introduction of a demand-responsive transport system to the residents of Schorndorf. Besides the educational purpose, it allows to study its effects on knowledge, attitude and acceptance of DRT. A quasi-experimental research design that is premised on the pre- and post-game comparison of experimental and control group will be used to test the effects of the game. Based on the evaluation of B.u.S. the game will be refined to further improve knowledge acquisition, attitude and acceptance as well as user experience. After this iteration, the game will be provided for the whole population of Schorndorf.

Due to the games generic game concept, B.u.S. could be used in operation areas of existing DRT systems to enhance non-users acceptance towards the bus system. It is as well conceivable to transfer the game concept to different transport and mobility contexts. Research projects that address new mobility services could benefit from the introduced gaming approach as it enables discovering and experiencing a transport system in an interactive and immersive way. For example, driverless vehicles might be a promising field of serious game application as prospective users of driverless vehicles could explore, try out and get familiar with the system`s concept and restrictions within the protected space of a game before actual operation.

The paper demonstrated major advantages of using serious games as supportive tool for transport system providers. If designed systematically and used consequently, games could be an important mosaic in convincing people to shift their mobility decisions from individual towards public transport systems.

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