

The use of gamification to change commuters' mobility behavior: A literature review

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Abstract

From current research projects at the University of Applied Sciences we learned that changing mobility behaviour is very difficult to achieve. Nevertheless, to reduce negative mobility impact and support people in their daily commute, we investigated the effects of gamification in the context of commuting.

Through conducting a structured literature review this paper aims to identify elements used in gamification to change users' mobility behaviour towards selecting more sustainable choices. The main challenge when doing this structured literature review was to define accurate search strings to cover our research question followed by selecting relevant papers and setting up a clear matrix for presenting the identified results. The research question answered in this paper is: What gamification elements and transport modes are employed in studies on gamification for commuter behaviour? Our paper follows the approach of Liberati et. al. [1] for systematic literature reviews. We retrieved 260 studies, 23 of them were identified for the thematic analysis. Private motorized individual transport, public transport, active mobility, and mobility sharing are the four major types of transportation modes which were identified after screening the 23 studies. Points & leaderboards, badges and quests/challenges are the main gamification elements which are identified after screening the 23 relevant papers. The positive effects of the individual elements are shown in the discussion and conclusion section.

Keywords

Gamification, behavioral change, smart and playful cities, mobility service, commuter, systematic literature review

1 Introduction

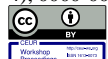
Transport emission account for one-fifth of the global CO₂ emissions and thereof 41% the passenger car is accountable for [2]. Rapid growth of urban population and vehicle numbers has led to new requirements for solving congestion and emission problems [3–5]. Commuting to work contributes to this congestion and emission

problems. The term commute refers to a journey that is non-discretionary and undertaken frequent between home and work [6, 7]. Environmentally friendly solutions such as shared-use vehicle right-of-way lanes, bicycle infrastructure improvements, downtown driving fees, and public transportation have been explored to significantly improve the devastating congestion and emissions problems in urban and catchment areas. These approaches all have in common that they are costly, reduce comfort for motorists, and require

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changes in commuters' work routines [8]. It would be better to continue to provide mobility per se for everyone, but in a user- and environmentally friendly manner. Mobility is defined as the potential for movement and the ability to get from one place to another using one or more modes of transport to meet daily needs. As such, it differs from accessibility, which refers to the ability to access or reach a desired service or activity [9]. One measure to reduce traffic congestion and emissions in urban areas is ridesharing. The term ride sharing is used for several concepts of shared use of mobility in the literature. Ridesharing means the sharing of a motor vehicle to share costs (non-profit) or to compensate the driver (i.e., paid service), with participant billing (for-profit) by the driver and one or more passengers [10]. It represents a useful complement to other forms of mobility, but the behavioral changes required to do so generally take time. Gamification has been considered one of the most popular persuasive technologies to change user behavior towards sustainability. Gamification is defined by Sgueo as “the use of game-design elements (e.g., rankings, levels, and badges) into non-game contexts”, implying playful dynamics such as an artificial conflict among users (competition), a set of rules to govern such conflicts and quantifiable outcomes (rewards) [11]. With gamification an environment is created in which intrinsic motivation encourages individuals to change their behavior in a desired way. [12].

Moreover, mobile apps for ride sharing used gamification to incentivize more environmentally friendly travel modes such as public transport [13]. In recent years, Buningh et al. implemented a gamified system for stimulating company employees to choose sustainable means of commuting to work [7]. One major challenge is to encourage commuters to use alternative modes of transportation (than the private motorized individual vehicle), while including them in the pervasive game. The building of a community of traffic participants (including motorists, bicyclists, public transport users, etc.) via the use of a website and a mobile application is a key aspect to make [8].

Transport policy is one of the most appropriate public areas suitable for gamification. It is characterized as a derived demand because transport is necessary to fulfill demands at the destination e.g., work, study, or leisure activity. For the effective application of gamification in the mobility field transport must be incorporated as a derived demand [8]. When behavioural change in

the context of travelling shall occur, according to Yen et. al. ”gamification can be designed either to impact on the derived demand itself and/or the end point activity for which transport is demanded“ [8].

Policymakers therefore have a choice in implementing gamification in the transportation context in practice. In a derived demand intervention for transportation, gamification can either target activities required by the travel behavior (i.e., completing the trip) or attempt to characterize transportation in that it is bundled including the goods or services that are consumed only at the end of the trip.

If the aim is to relieve congestion in the transport network by political means, for example, two different concepts can be applied. First, as a substitute for the own car, a gamification system for public transport could be developed. Here, a concentration of the game elements on variables related to the travel behavior, e.g. travel costs or travel modes, would be necessary. As a second option, gamification could target the bundling of travel and consumption of goods or services at the end of the trip. Accordingly, the game structure would have to be geared towards the use of public transport as access to, for example, soccer matches, enabling, for example, participation in a lottery for a ticket to the next soccer match. In both cases, gamification provides an incentive for car owners to see public transportation as an experience and thus increase their use of it. In practice, this has already been used successfully to achieve change [8]. The literature review aims to understand this change and answers the following research question:

(RQ) *What gamification elements and transport modes are employed in studies on gamification for commuter behavior?*

2 Method

We conducted a systematic literature review to identify what gamification elements and transport modes are used to aid behavioral change towards sustainable commuting. The authors drew from the four-phase model of the PRISMA statement by Liberati et al. The model proposes structuring information flow within an identification, screening, eligibility, and inclusion phase, to improve the reporting of the systematic review [1]. This approach was used as it is a well-established approach for systematic reviews. For

the literature review, the database Scopus and the search engine Primo of the University of Applied Sciences Upper Austria were used. Primo covers the following databases: ACM, Belz Juventa, EBSCO Business Source Elite, Emerald Collections, Hanser E-books, IEEE/IEL, Nomos eLibrary, OECD, Sage Humanities and Social Science Package, ScienceDirect College Edition, SpringerLink Portal, Taylor and Francis, UTB-Studi-E-Book, publishing house Austria E-Library, and Wiley-Online Library. The titles of the search were downloaded on the 24th of January and the review was conducted between January and February 2023. Table 1 shows the metadata and the search strings used in Primo and Scopus. Scopus covers peer-reviewed studies and in Primo peer reviewed studies were included in the search results.

Table 1
Databases and search string used

Database	Searched Metadata	Search string
SCOPUS	Title, All	TITLE (gamif*) AND (mobility AND (service OR commut*) AND (chang* OR behav*))
PRIMO	Title, All	TITLE (gamif*) AND (mobility AND (service OR commut*) AND (chang* OR behav*))

Table 2
Number of studies per database

Database	Search date	Number of studies	Exclusion criteria
SCOPUS	24.01.23	160	
PRIMO	24.01.23	100	non peer-reviewed

The search string includes the keyword gamif* in the title search to include the keywords gamification and gamify. The remaining keywords used are searched for in all the text passages of the publications. The combination of the keywords mobility and service was used to include publications related to the topic mobility

as a service and other services related to mobility. The search term mobility and commut* was used to include studies in relation to commuting, commute and commuters and to narrow the results that mobility retrieves stand-alone. The keywords chang* or behave* are included to include the topic of behavioral change and generally changes induced by gamification.

Having the search string defined we retrieved 260 studies. Table 2 shows the results of the literature search in each database. After the duplicates were removed 223 studies remained. Inclusion and exclusion criteria were defined to find relevant studies for our future research. The inclusion and exclusion criteria are shown in Table 3.

Table 3
Inclusion and exclusion criteria

Inclusion Criteria	Rationale
Publication in peer-reviewed journal	Practitioner documents that reflect current scientific status about the use of gamification to change mobility behavior
Paper discusses and describes the effects of gamification on changing mobility behaviors	The focus of this research is to identify effects gamification has on changing mobility behaviors
Exclusion criteria	Rationale
Paper was not written in English	English is the language that the author can read and comprehend
No access to full paper available	Only if the full paper can be processed, the relevance of a paper can be determined
Access to requested paper not granted/not granted in time for deadline	Only if the full paper can be processed, the relevance of a paper can be determined

After revising the title and abstract and applying the inclusion and exclusion criteria on the 223 studies, 29 studies remained. These 29 studies were full text analyzed. 6 studies were excluded because they were missing contextual connections to the research topic. 23 studies were

identified as relevant for further thematic analysis. The review procedure is shown in Figure 1.

In the thematic analysis, we investigate the distribution of the 23 relevant studies on the four modes defined in the results section: motorized individual transport, public transport, active mobility, and mobility sharing. The gamification elements that were evaluated within the relevant studies are categorized as well as the benefit, incentive or reward that was offered to users is characterized. The transport modes, gamification elements and benefits, incentives and rewards are presented in the results section.

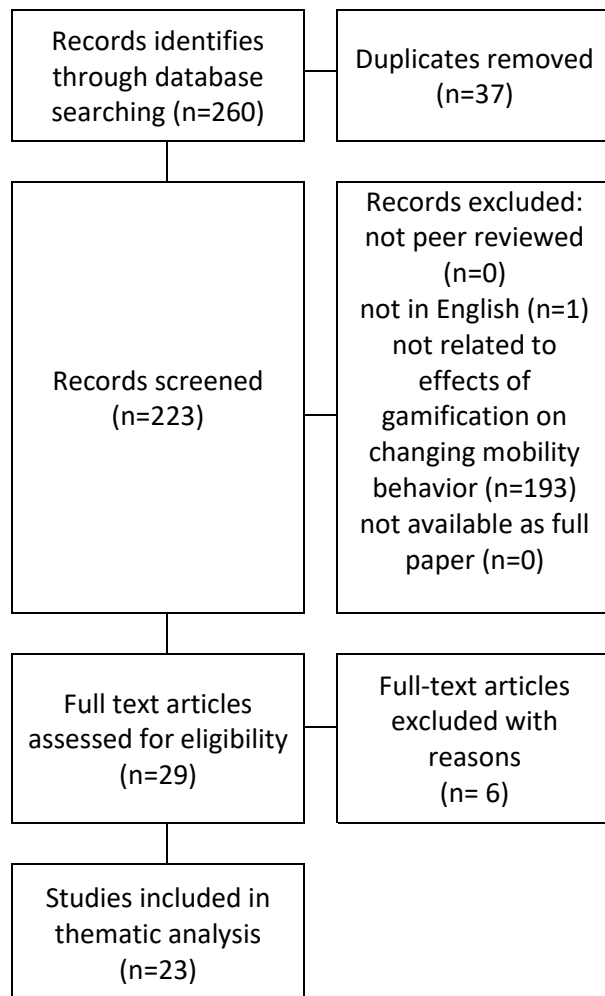


Figure 1: Review procedure

3 Results

In this section the results of the 23 studies related to gamification in the mobility sector are discussed to answer the research question. The title, authors, research or deployment project, publication year and reference numbers given are shown in Table 4. Research project refers to projects based on literature and comparison

thereof whereas deployment projects are projects realized and tested in real-life conditions.

The following paragraphs explain the categories used in Table 5, which compares the literature findings. Private motorized individual transport, public transport, active mobility, and mobility sharing are the four major types of transportation modes which were identified after screening the 23 studies.

Motorized (private) individual transport contains all individual transportation systems which are run by an internal engine e.g., car (including e-car) or motorcycle. E-bikes and E-scooters are excluded and are part of the active mobility transportation type.

All sorts of transportation with which people travel together on designated routes (e.g. buses, trams, tubes) were clustered under the term *public transport*.

Active mobility refers to all kind of mobility which requires an active physical input activity. Though some e-bikes can drive without active pedal they are still clustered under active mobility due to the strong similarity with normal bikes.

Mobility sharing covers all transportation services and devices (e.g. cars or bikes) which are shared among each other. It includes car sharing schemes as well as ride sharing.

Points & Leaderboards, Badges and quests/challenges are the main gamification elements which are identified after screening the 23 papers. These elements refer to a gameplay mechanism through which users should be motivated to engage more with the system.

Points indicate how successful a task, or a prior defined *quest* has been completed. Users can compare their score with the other users score on *leaderboards*, which leads to competition amongst users [14].

Badges that are provided are mostly known in advance to encourage the user to complete personal goals without direct competition [15]. They have the same principle as medals and show achievements which are usually received after a series of tasks has been completed [3]. Badges are used to further reward a player's performance in terms of achievements by providing a collective visual representation [16].

Quests/challenges: With a given challenge users desired behavior can be accomplished plus interest and participation is maintained over time. [3]. To make challenges more effective in terms of behavior change, quests and challenges tailored to the participant turned out to be most engaging and increased the user experience [16].

Benefit/rewards/incentives: To achieve changes in certain behavior, rewards through incentive measures must be individual performance related. Rewarding well performing participants can increase the motivation to change direction in a desired way. [8] Travel demand management often adopts incentives as an instrument for change in travel behavior e.g. discount for public transport fares during off-peak times [8].

After screening the elected literature benefits in the context with gamification can be classified into direct tangible or indirect tangible benefits. *Direct tangible* benefits are financial rewards, discounts on products or points which can be redeemed further for rewards.

Indirect tangible benefits lead to money and time savings through inclusion of information and feedback from the application [17].

Having defined the categories used in this paper, Table 5 shows the results of our research about gamification in the field of the different transport modes and which different gamification elements have been mentioned in the publications.

Active mobility was the most examined transportation mode with a total of 15 paper covering the topic. 11 articles had references to public transportation. With 10 references mobility sharing and 9 references motorized individual transport are the least mentioned transportation modes.

The three main gamification elements points & leaderboards, badges and quests were identified in the literature. From 23 screened papers 9 covered a topic including badges and 12 referred to a point-based gamification system, some having both. Only 3 covered a quest-based gamification element. Direct tangible benefits have been addressed by 15 publications, indirect tangible benefits by 17.

4 Discussion and conclusion

The goal of this literature review was to identify what gamification elements and transport modes are employed in studies on commuter behavior. We investigated how gamification influences mobility behavior and choices made by the users. Overall, it can be concluded that using gamification elements had a positive effect e.g. increased bike sharing users [30], behavioral change towards more eco-friendly transport choices [3, 8, 16, 17], a more eco-friendly driving behavior [15] or an improved quality of

interaction with the mobility service used [27]. The effects of gamification were never stated as having a negative influence, yet measurable data are scarce.

Through our review process we discovered that within the peer-reviewed articles only few studies present measurable results on the impact of gamification on commuter mobility behavior e.g. decreased CO2 emissions or quantifying the impact of direct tangible rewards on application usage. For instance, Kracheel et al. identified and quantified which gamification elements users respond by testing through mock-up games [19]. Minnich measured the impact of gamification on new customer numbers [32] or Ebermann et al. measures the influence of specific functions within a persuasive system [21]. Yet, a research gap exists, further research could investigate and define indicators for making the effects of gamification on mobility behavior tangible or focus on making impacts measurable.

Another limitation of this review is that non-peer-reviewed literature was excluded in the search. Projects, experiments, and applications that were not scientifically published are therefore not covered. Further research could include project data bases e.g. of EU-Projects and thus contribute to real-life experiences and as well as found data.

Rewards for sustainable mobility behavior makes travel more interesting [3].

For further research the search string should also include GAME* as in this review the search was limited to GAMIF* and thus important publications might have been missed. In this review it was not included due to capacity reasons as the retrieved studies are significantly higher including game in the search string. The review shows that benefits/rewards/ incentives, no matter if direct tangible, indirect tangible, or their combination are vital elements when gamifying commutes or other travels.

Table 4

Relevant literature used within the review including designated study ID, author, title, journal, research or deployment project and year

Study ID	Authors	Title	Journal	Research (R) or Deployment Project (D)	Year	Reference
S01	McCall R,Koenig V,Kracheel M	Using gamification and metaphor to design a mobility platform for commuters	JMHCI	R	2013	[18]
S02	Kazhamiakin R,Marconi A,Perillo M,Pistore M,Valetto G,Piras L,Avesani F,Perri N	Using gamification to incentivize sustainable urban mobility	ISC2	D	2015	[7]
S03	Kracheel M,McCall R,Koenig V	Playing with traffic: An emerging methodology for developing gamified mobility applications	IGI Gobal	R	2015	[19]
S04	Kazhamiakin R,Marconi A,Perillo M,Pistore M,Valetto G,Piras L,Avesani F,Perri N	A gamification framework for the long-term engagement of smart citizens	ISC2	D	2016	[20]
S05	Ebermann C,Brauer B	The role of goal frames regarding the impact of gamified persuasive systems on sustainable mobility behavior.	ECIS 2016	R	2016	[21]
S06	Wunsch M,Stibe A,Millonig A,Seer S,Chin RC,Schechtner K	Gamification and social dynamics: Insights from a corporate cycling campaign	LNCS	D	2016	[22]
S07	Vlahogianni EI,Barmponakis EN	Gamification and sustainable mobility: Challenges and opportunities in a changing transportation landscape	IET	R	2017	[23]
S08	Lieberoth A,Holm Jensen N,Bredahl T	Selective psychological effects of nudging, gamification and rational information in converting commuters from cars to buses: A controlled field experiment	TRF	D	2018	[24]
S09	Drakoulis R,Bellotti F,Bakas I,Berta R,Paranthaman PK,Dange GR,Lytrivis P,Pagle K,De Gloria A,Amditis A	A Gamified Flexible Transportation Service for On-Demand Public Transport	ITS	R	2018	[25]
S10	Olszewski R,Pałka P,Turek A	Solving “smart city” transport problems by designing carpooling gamification schemes with multi-agent systems: The case of the so-called “mordor of Warsaw”	Sensors	D	2018	[26]
S11	Volpi V,Parente GA,Pifferi G,Opromolla A,Medaglia CM	Improving quality of interaction with the mobility services through the gamification approach	LNCS	R	2018	[27]

Study ID	Authors	Title	Journal	Research (R) or Deployment Project (D)	Year	Reference
S12	Cardoso B,Ribeiro M,Prandi C,Nunes N	When gamification meets sustainability: A pervasive approach to foster sustainable mobility in Madeira	ACM	D	2019	[14]
S13	Yen BT,Mulley C,Burke M	Gamification in transport interventions: Another way to improve travel behavioural change	Cities	R	2019	[8]
S14	Dodi IA	Biregional cooperation for advancing Gamification in Transport Policies and Infrastructure in the European Union and Latin America and the Caribbean	Europolity	R	2020	[28]
S15	Pinto BM,Rossetti RJ	Simulation of Gamification Elements to Promote Carpooling in a Closed Community	ISC2	R	2020	[29]
S16	Douglas BD,Brauer M	Gamification to prevent climate change: a review of games and apps for sustainability	Current opinion in	R	2021	[12]
S17	Pasca MG,Guglielmetti Mugion R,Toni M,Di Pietro L,Renzi MF	Gamification and service quality in bike sharing: an empirical study in Italy	TQM	R	2021	[30]
S18	Kazhamiak R,Loria E,Marconi A,Scanagatta M	A Gamification Platform to Analyze and Influence Citizens' Daily Transportation Choices	ITS	D	2021	[16]
S19	Luger-Bazinger C,Hornung-Prähauser V	Innovation for Sustainable Cities: The Effects of Nudging and Gamification Methods on Urban Mobility and Sustainability Behaviour	AGIF	D	2021	[31]
S20	El Hafidy A,Rachad T,Idri A,Zellou A	Gamified mobile applications for improving driving behavior: A systematic mapping study	MIS	R	2021	[15]
S21	Wang W,Gan H,Wang X,Lu H,Huang Y	Initiatives and challenges in using gamification in transportation: a systematic mapping	ETRR	R	2022	[3]
S22	Guo Y,Peeta S,Agrawal S,Benedyk I	Impacts of Pokémon GO on route and mode choice decisions: exploring the potential for integrating augmented reality, gamification, and social components in mobile apps to influence travel decisions.	Transportation	R	2022	[17]
S23	Minnich A	Gamification in the transport sector: Quasi-experimental evidence from a bicycle navigation app	Transportation research	D	2023	[32]

Table 5

Output table comparing the applied transport modes and gamification elements per study

	Transport mode					Gamification elements			
	Motorized individual transport	Public transport	Active mobility	Mobility sharing	Points & leaderboards	Badge	Quest / challenges	Indirect tangible benefit	Direct tangible benefit
S01	x								x
S02			x		x	x		x	x
S03	x	x	x	x	x				x
S04		x	x		x	x		x	x
S05			x						
S06			x				x	x	
S07	x	x	x	x	x	x		x	x
S08	x	x			x			x	x
S09		x						x	x
S10	x			x				x	x
S11		x		x				x	x
S12		x						x	
S13		x	x					x	x
S14	x	x	x	x	x			x	x
S15				x	x	x			
S16			x	x					
S17			x	x	x	x		x	
S18	x	x	x	x	x	x	x	x	x
S19			x		x			x	
S20	x							x	x
S21			x		x	x	x		
S22	x	x	x	x	x	x	x	x	x
S23			x			x		x	x
Sum	9	11	15	10	12	9	4	17	15

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