Gamified eco-driving: A systematic literature review

Eetu Wallius [1] and Dicle Berfin Köse [2]

[1] *Tampere University, Kalevantie 4, 33100 Tampere, Finland*
[2] *BI Norwegian Business School, Nydalsveien 37, N-0484 Oslo, Norway*

Abstract

Due to the ongoing social turmoil and the climate crisis, passenger road vehicles face increasing pressure to improve energy-efficiency. A central aspect of this endeavor is to motivate drivers to adopt a more energy-efficient driving style. In that respect, the use of information systems (IS) can be a game changer. Among motivational IS, especially gamification is a promising approach to encourage eco-driving as it has the potential to direct user behavior by providing positive experiences like those experienced when playing games. However, despite the emerging interest on gamified eco-driving, there is a lack of comprehensive understanding on how gamification has been applied in the eco-driving domain, hindering the understanding of how it should be designed in this context and what areas need further research inquiries. Therefore, this study synthesizes existing research on gamified eco-driving (17 studies) through a systematic literature review. Based on the results, performance-based and social gamification are most applied, while they aim at encouraging a relatively comprehensive set of different eco-driving behaviors by addressing the motivational hurdles related to eco-driving. We encourage future research endeavors to consider a wider variety of gamification types and be more transparent about the goals of implementing gamification and evaluate the psychological effects accordingly.

Keywords

Energy efficiency, eco-driving, gamification, systematic literature review

1. Introduction

Energy plays a deterministic role in world history: its transmission and transformation have sustained and delimited all living organisms big and small and affected societies and civilizations from prehistory to the modern era [1]. However, contemporary energy production and use pose many environmental, health-related and social problems. Most notably, energy-related CO_2 emissions have grown to a record high in 2021 [3]. Accordingly, with the European Climate Law, which came into effect in July 2021, the European Union aims to reduce its greenhouse gas emissions by 55% compared to 1990 levels [4].

One of the main contributors of greenhouse gas emissions is the global transportation sector. In 2020, transportation was the biggest contributor (27%) of greenhouse gas emissions in the US [5]. Similar data are seen in the EU as well: transportation is responsible for nearly a quarter of Europe's greenhouse gas emissions, with road transport being the biggest contributor (72.8%) and having the highest energy demand (73.4%) [6]. This poses pressure to improve transportation energy-efficiency, i.e., to develop processes, products, and tasks so that they use lower amounts of energy while maintaining their level of performance [7]. The strategies for reducing these levels include e.g., the electrification of transportation [8]. However, considering the fact that passenger road vehicles are the biggest contributor of CO_2 emissions in the transportation sector [9], road vehicle drivers can be the starting point in efforts to induce energy efficiency.

7th International GamiFIN Conference 2023 (GamiFIN 2023), April 18-21, 2023, Lapland, Finland.
EMAIL: eetu.wallius@tuni.fi; dicle.b.kose@bi.no
ORCID: 0000-0003-3251-7314 (A. 1); 0000-0002-1256-1310 (A. 2)

Given these points, vehicle drivers should be inspired and encouraged to drive in a more energy-efficient manner. In that respect, the use of information systems (IS) in the transportation domain can be a game changer, with its effects on the behavior of road vehicle drivers. Through IS, vehicle drivers can be provided with the right incentives and motivation to improve their driving behavior.

Among motivational IS, gamification has become the most prominent design approach due to the rapidly increasing attention it has attracted among practitioners and academia [10]. Gamification employs game-like design to provide users with similar gameful experiences as games do with the aim of directing their behaviors [11]. To serve the environmental and social sustainability goals related to energy efficiency, gamification can transform driving in an energy-efficient manner to feel like playing a game.

Gamification, however, is not a homogenous type of design or a 'one size fits all' solution. The experiences induced by gameplay are diverse, ranging from a sense of achievement after overcoming in-game challenges, to becoming immersed in a virtual world, among others. This diversity is also reflected in gamification design, which is an umbrella for elements such as leaderboards, social networking, narratives, and goalsetting that draw inspiration from games [12]. To determine how gamification should be designed and implemented, it is necessary to consider users' individual differences, targeted behaviors, and other contextual factors, as they influence what types of strategies might work best in achieving a sustained behavioral change [13].

While gamification has been increasingly investigated in the driving context, the corpus lacks comprehensive understanding of how gamification has been applied to encourage energy-efficient driving. Moreover, there exists no understanding of which aspects of gamified energy-efficient driving require further investigation. Therefore, in this study, we synthesize existing research investigating the use of gamification to encourage energy-efficient driving to provide an overview and identify avenues for future research.

2. Background

2.1. Eco-driving behaviors

Eco-driving is the process of operational decisions regarding vehicle driving that reduces energy consumption and increases mileage per unit of consumed energy [14]. Eco-driving can also include strategic (e.g., vehicle choice and maintenance) and tactical decisions (e.g., route choice, vehicle load) [14], [15]. However, for the purpose of this study we only focus on the operational decisions, in other words, driver behavior. The operational decisions that affect mileage are idling, speeding, use of cruise control, use of air conditioner, and aggressive driving [15]. It was shown by several investigations that operational decisions can reduce fuel consumption by 5-30% [16].

Governments started to require energy-efficient driving for driver's license; however, several studies show that energy-efficient driving deteriorates in time [17]. Accordingly, the number of driver assistance systems are increasing. For example, State Farm and DriveSmart encourage eco-driving by providing feedback on acceleration, braking, cornering, and speeding [18], [19]. Previous research shows the benefits of these systems in inducing eco-driving practices, particularly of gamification in helping drivers retain their energy efficient driving habits (e.g., [17], [20]).

2.2. Gamification

To systematically analyze and find future research directions, we analyzed the existing studies considering two gamification perspectives: gamification taxonomy [21] and the gamification affordances [22].

Gamification was conceptualized to comprise three levels - affordances, psychological outcomes, and behavioral outcomes, all of which are situated in a certain context [22]. Affordances are the perceived or actual elements and mechanisms commonly used in games [23]. Psychological outcomes are the psychological experiences gamification aims to induce and can be in the form of feelings of mastery and competence, relatedness, autonomy, and enjoyment. Behavioral outcomes are the activities and behaviors that the gamification supports.

Gamification taxonomy classifies gamification elements into five groups: performance, ecological, social, personal, and fictional [21]. Performance elements are used to provide feedback to the users and comprise point, progression, level, stats, and acknowledgement elements. Ecological elements are the properties of the gamification context and comprise chance, imposed choice, economy, rarity, and time pressure. Social elements enable users to interact with others and comprise competition, cooperation, reputation, and social pressure. Personal elements are related to the users and make their experience more meaningful. This group comprises elements of sensation, objective, puzzle, novelty, and renovation. Fictional elements tie user experience with the context through the elements of narrative and storytelling.

The resulting framework adopted for this study is presented in Figure 1. The framework comprises two dimensions. The first dimension presented in the horizontal axis stands for the affordances that induce psychological and behavioral outcomes. In the vertical axis, affordances and their effects are grouped into gamification types. Accordingly, affordances that belong to different gamification types may induce different types of psychological and behavioral outcomes.

Figure 1: Affordances of gamification types

3. Methods

To provide an overview of the corpus investigating gamified eco-driving, and identify avenues for future research, we conducted a systematic literature review. As the main aim is to identify trends in existing research, the review can be considered as descriptive [24].

To comprehensively identify studies relevant to our research aims, we used the Scopus indexing and citation database in the literature search. We considered keywords related to eco-driving (e.g., eco-driving, fuel consumption, fuel saving), and gamification (e.g., gamification, reality-enhanced games, game element). After conducting pilot searches to identify the suitable search terms, we used the search string *(gamif* OR "persuasive interface" OR "persuasive smartphone application" OR "persuasive strategy" OR "persuasive technolog*" OR "reality-enhanced gam*" OR "serious gam*" OR "game element") AND ("eco-driv*" OR "eco driv*" OR ecodriv* OR "eco-efficient driv*" OR "fuel consumption" OR "fuel efficiency" OR "environmentally friendly driv*" OR "fuel saving")* in the titles, abstracts and keywords, while limiting the search to include articles, conference publications and book chapters.

A total of 39 studies were retrieved with the search string. The following inclusion criteria were used to filter out studies not relevant to our analysis: (1) The manuscript is written in English (0 excluded), (2) The manuscript reports a peer-reviewed study (0 excluded), (3) The manuscript proposes a design or implementation related to in-situ gamification (17 excluded), (4) The manuscript is related to eco-driving (2 excluded), (5) The study is available to the authors (3 excluded). Two researchers independently screened all the studies for inclusion and discussed on the disagreed studies. Finally, 17 manuscripts met all the inclusion criteria, as depicted in figure 2.

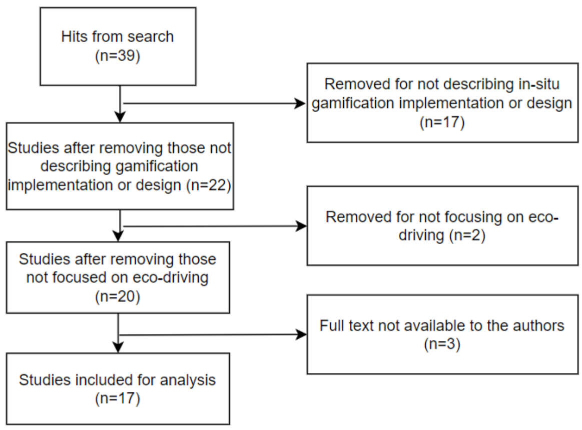

Figure 2: Literature selection process

Each of the 17 manuscripts that met the inclusion criteria were analyzed by a single researcher. The following information was extracted from each manuscript: implemented or considered gameful motivational affordances (e.g., points, storytelling), psychological outcomes, and targeted eco-driving behaviors.

4. Results

Overall, the analyzed corpus proposed interventions belonging to all the five gamification categories (Table 1). Despite the relatively small number of studies, these implementations were evaluated in terms of diverse psychological outcomes, as well as a rather comprehensive set of different eco-driving behaviors.

Performance-based gamification features (n=13, [17], [25]–[36]) were the most used, followed by social gamification (n=12, [17], [20], [26], [27], [29]–[33], [35]–[37]), while personal (n=4, [27], [28], [32], [36]), ecological (n=2, [27], [33]), and fictional (n=1, [27]) were much less common.

In terms of psychological outcomes, implementations using performance-based gamification were mostly evaluated in terms of usefulness (n=3, [26], [35], [36] and fun or joy (n=2, [29], [35]), while other psychological outcomes were only evaluated by a single study (i.e., engagement [27], attitude [27], perceived clarity [27], perceived effectiveness [28], efficiency [29], perceived pressure [29], perceived distraction [29], perceived influence on eco-driving [29], system acceptance [26], ease of use [26], satisfaction [34], usability [36]). The most evaluated behavioral outcomes in studies implementing performance-based gamification were driving speed (n=4, [17], [26], [31], [35]) followed by fuel or energy consumption (n=3, [17], [29], [35]), braking (n=2, [29], [35]), and acceleration (n=2, [29], [35]). Other behavioral outcomes were only evaluated by a single study each (i.e., coasting [29], even driving [29], engine speed [31], driving aggressiveness [31], coasting [29]).

The most evaluated psychological outcomes resulting from implementations using social gamification were usefulness (n=2, [20], [36]) and fun or joy (n=2, [20], [29]), while the rest were only evaluated by a single study each (i.e., system acceptance [26], usefulness [26], ease of use [26], engagement [27], attitude [27], perceived clarity [27], information value [20], usability [36], perceived efficiency [29], perceived pressure [29], perceived distraction [29]). The most common behavioral outcomes among studies implementing social gamification were driving speed (n=3, [17], [38], [39]), average energy or fuel consumption (n=3, [17], [20], [29]), and braking (n=2 [17], [29]). Outcomes evaluated by a single study each were coasting [29], even driving [29], acceleration [29], and driving aggressiveness [31].

Implementations using personal, ecological, and fictional gamification were only evaluated in terms of psychological outcomes. For personal gamification, the outcomes were usability [36], usefulness [36], perceived clarity [27], engagement [27], attitude [27], and perceived effectiveness [28], while both ecological and fictional were evaluated in terms of perceived clarity [27], engagement [27], and attitude [27].

5. Discussion and future avenues

Overall, the corpus focused on performance-based and social gamification, while the implementations mainly aimed at improving eco-driving by encouraging drivers to adopt optimal driving speed or by encouraging an overall eco-friendly driving to decrease fuel consumption. The psychological outcomes derived from gamification implementations related to both utilitarian and hedonic aspects of gamification, most common being usefulness, and fun or joy. Overall, this implies that performance and social gamification features support eco-driving behaviors by both providing the driver with information that they can use to adapt their behaviors as well as motivating eco-driving by providing hedonic pleasure.

Eco-driving behaviors typically lack any form of direct feedback, or the possibility to reliably monitor one's performance, which might become a motivational hurdle for engaging in eco-driving. Thus, the prevalence of performance-based features suggests that most studies use gamification to imbue eco-driving with feedback that supports drivers' decision-making, while providing a sense of acknowledgement for behaving in a desired manner [20]. However, another possible reason for performance-based gamification being the most common category is that features such as points or feedback are easily implemented onto the driving tasks without compromising driving safety due to e.g., distraction [40].

On the other hand, social features were also commonly applied. The aim of social gamification is to provide interaction among gamification users – another feature that is inherently absent in eco-driving, during which individuals are confined to their vehicles, allowing limited possibilities to interact with and compare one's behavior to others [41].

Personal, ecological, and fictional gamification types were less prevalent, and were

Table 1. Synthesis of the results

Gamification types	Affordances	Psychological Outcomes	Behavioral Outcomes
Performance (n=13)	Points or score (n=10) Feedback (n=9) Badges (n=4) Levels (n=4) Awards, trophies, rewards (n=3) Performance statistics (n=2) Hints (n=2)	Usefulness (n=3) Fun, joy (n=2) Engagement (n=1) Attitude (n=1) Perceived clarity (n=1) Perceived effectiveness (n=1) Perceived efficiency (n=1) Perceived pressure (n=1) Perceived distraction (n=1) Perceived influence on driving (n=1) System acceptance (n=1) Ease of use (n=1) Satisfaction (n=1) Usability (n=1)	Driving speed (n=4) Average energy or fuel consumption (n=3) Braking (n=2) Acceleration (n=2) Coasting (n=1) Even driving (n=1) Engine speed (n=1) Driving aggressiveness (n=1) Coasting (n=1)
Social (n=12)	Leaderboard or ranking (n=8) Social comparison (n=3) Social networking (n=1) Common goals (n=1) Competition (n=2) Cooperation (n=1)	Usefulness (n=2) Fun, joy (n=2) System acceptance (n=1) Usefulness (n=1) Ease of use (n=1) Engagement (n=1) Attitude (n=1) Perceived clarity (n=1) Information value (n=1) Usability (n=1) Perceived efficiency (n=1) Perceived pressure (n=1) Perceived distraction (n=1) Perceived influence on driving (n=1)	Driving speed (n=3) Average energy or fuel consumption (n=3) Braking (n=2) Coasting (n=1) Even driving (n=1) Acceleration (n=1) Driving aggressiveness (n=1)
Personal (n=4)	Challenges or objectives (n=4)	Usability (n=1) Usefulness (n=1) Perceived clarity (n=1) Engagement (n=1) Attitude (n=1) Perceived effectiveness (n=1)	-
Ecological (n=2)	Collectibles (avatar outfits) (n=1) Lootboxes (n=1)	Perceived clarity (n=1) Engagement (n=1) Attitude (n=1)	-
Fictional (n=1)	Storytelling (n=1)	Perceived clarity (n=1) Engagement (n=1) Attitude (n=1)	-

only evaluated in terms of psychological outcomes. While the lack of personal and ecological gamification features is surprising, as they can provide meaning to the user for example by providing them with clear eco-driving objectives, which is a feature that is easily implemented onto the driving task, the relative absence of fictional features might be explained by the risks they involve. For example, by immersing the user into a gameful world using narrativization might cause them to become detached and distracted from the driving task, thus compromising safety which is to be considered when designing such gamification.

Nevertheless, based on the review, we encourage future research to consider gamification types beyond the performance and social. Especially fictional elements, such as narratives could be an effective way to support motivation towards eco-driving when accounting for the safety risks, as narrativization and storytelling is arguably a promising way to promote sustainable behaviors [42]. Additionally, we encourage ecological gamification implementations, as they foster sustained interest, potentially leading long-term effects on eco-driving behaviors [20].

Furthermore, we encourage future research endeavors to be more transparent about the goals of implementing gamification and evaluate the psychological effects accordingly. For example, while many studies implemented social gamification features, whose goal is to primarily foster connectedness, competitiveness or social pressure [20], the evaluated psychological outcomes were mainly related to perceptions of utility, such as usefulness, or to more abstract hedonic outcomes, such as joy. Thus, the corpus provides little evidence of how gamification implementations reach the goals related to imbuing eco-driving with a gameful experience, and what types of gameful experiences might be the most effective in promoting eco-driving.

The limitations of this study include the relatively small number of analyzed studies which hinders the understanding of what types of gamification strategies are the most suitable for encouraging eco-driving. Moreover, while we conducted pilot searches to identify relevant keywords, it is possible that relevant keywords were missed, especially in relation to alternatives to fuel-driven vehicles.

6. References

[1] V. Smil, “World History and Energy,” *Encyclopedia of Energy*, vol. 6, pp. 549–561, 2004, doi: 10.1016/b0-12-176480-x/00025-5.

[2] World Bank Group, “Commodity markets Outlook. The Impact of the War in Ukraine on Commodity Markets,” 2022.

[3] International Energy Agency, “Global Energy Review: CO2 Emissions in 2021,” 2022.

[4] European Commission, “European Climate Law | Climate Action,” *European Union*, 2021. https://ec.europa.eu/clima/policies/eu-climate-action/law_en (accessed Sep. 08, 2021).

[5] United States Environmental Protection Agency, “Fast Facts on Transportation Greenhouse Gas Emissions,” *epa.gov*, 2022. https://www.epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions (accessed Jul. 20, 2022).

[6] European Commission, “Transport emissions,” *ec.europa.eu*. https://ec.europa.eu/clima/eu-action/transport-emissions_en (accessed Jul. 20, 2022).

[7] M. Lackner, “Energy Efficiency: Comparison of Different Systems and Technologies,” in *Handbook of Climate Change Mitigation and Adaptation*, Springer International Publishing, 2022, pp. 381–456. doi: 10.1007/978-3-030-72579-2_24.

[8] S. McBain and J. Teter, “Tracking Transport 2021 - Analysis - IEA,” 2021.

[9] International Energy Agency, “Transport: Improving the sustainability of passenger and freight transport,” *iea.org*, 2021. https://www.iea.org/topics/transport (accessed Jul. 20, 2022).

[10] J. Koivisto and J. Hamari, “The rise of motivational information systems: A review of gamification research,” *International Journal of Information Management*, vol. 45. Elsevier Ltd, pp. 191–210, Apr. 01, 2019. doi: 10.1016/j.ijinfomgt.2018.10.013.

[11] K. Huotari and J. Hamari, *Defining Gamification - A Service Marketing Perspective*. 2012.

[12] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, “From game design elements to gamefulness,” in *Proceedings of the 15th International Academic MindTrek*

Conference on Envisioning Future Media Environments - MindTrek '11, 2011, p. 9. doi: 10.1145/2181037.2181040.
[13] B. Morschheuser, L. Hassan, K. Werder, and J. Hamari, "How to design gamification? A method for engineering gamified software," *Inf Softw Technol*, vol. 95, pp. 219–237, Mar. 2018, doi: 10.1016/j.infsof.2017.10.015.
[14] T. Stillwater and K. S. Kurani, "Drivers discuss ecodriving feedback: Goal setting, framing, and anchoring motivate new behaviors," *Transportation Research Part F: Psychology and Behaviour*, vol. 19, pp. 85–96, 2013, doi: 10.1016/j.trf.2013.03.007.
[15] M. Sivak and B. Schoettle, "Eco-driving: Strategic, tactical, and operational decisions of the driver that influence vehicle fuel economy," *Transp Policy (Oxf)*, vol. 22, pp. 96–99, 2012, doi: 10.1016/j.tranpol.2012.05.010.
[16] Md. S. Alam and A. McNabola, "A critical review and assessment of Eco-Driving policy & technology: Benefits & limitations," *Transp Policy (Oxf)*, vol. 35, pp. 42–49, 2014, doi: 10.1016/j.tranpol.2014.05.016.
[17] V. C. Magana and M. Munoz-Organero, "GAFU: Using a Gamification Tool to Save Fuel," *IEEE Intelligent Transportation Systems Magazine*, vol. 7, no. 2, pp. 58–70, 2015, doi: 10.1109/MITS.2015.2408152.
[18] State Farm, "Drive Safe & Save™ Mobile - State Farm®," *State Farm*, 2020. https://www.statefarm.com/customer-care/download-mobile-apps/drive-safe-and-save-mobile (accessed Jan. 23, 2020).
[19] DriveSmart, "DriveSmart EN | DriveSmart is the app of the good driver. Now you can analyze how you drive, improve at the road and certify your driving. Welcome to the good drivers Community!," *DriveSmart*, 2020. http://drive-smart.com/ (accessed Jan. 23, 2020).
[20] M. Günther, C. Kacperski, and J. F. Krems, "Can electric vehicle drivers be persuaded to eco-drive? A field study of feedback, gamification and financial rewards in Germany," *Energy Res Soc Sci*, vol. 63, p. 101407, May 2020, doi: 10.1016/j.erss.2019.101407.
[21] A. M. Toda *et al.*, "Analysing gamification elements in educational environments using an existing Gamification taxonomy," *Smart Learning Environments*, vol. 6, no. 1, p. 16, Dec. 2019, doi: 10.1186/s40561-019-0106-1.
[22] J. Koivisto and J. Hamari, "The rise of motivational information systems: A review of gamification research," *Int J Inf Manage*, vol. 45, pp. 191–210, Apr. 2019, doi: 10.1016/j.ijinfomgt.2018.10.013.
[23] D. A. Norman, "Affordance, Conventions, and Design," *Interactions*, vol. 6, no. 3, pp. 38–43, 1999, [Online]. Available: http://www.jnd.org
[24] G. Paré, M. C. Trudel, M. Jaana, and S. Kitsiou, "Synthesizing information systems knowledge: A typology of literature reviews," *Information and Management*, vol. 52, no. 2, pp. 183–199, 2015, doi: 10.1016/j.im.2014.08.008.
[25] R. Massoud, R. Berta, S. Poslad, A. de Gloria, and F. Bellotti, "IoT Sensing for Reality-Enhanced Serious Games, a Fuel-Efficient Drive Use Case," *Sensors*, vol. 21, no. 10, p. 3559, May 2021, doi: 10.3390/s21103559.
[26] R. F. T. Brouwer, A. Stuiver, T. Hof, L. Kroon, J. Pauwelussen, and B. Holleman, "Personalised feedback and eco-driving: An explorative study," *Transp Res Part C Emerg Technol*, vol. 58, no. PD, pp. 760–771, Sep. 2015, doi: 10.1016/j.trc.2015.04.027.
[27] S. Nousias *et al.*, "Exploiting Gamification to Improve Eco-driving Behaviour: The GamECAR Approach," *Electron Notes Theor Comput Sci*, vol. 343, pp. 103–116, May 2019, doi: 10.1016/j.entcs.2019.04.013.
[28] P. di Lena, S. Mirri, C. Prandi, P. Salomoni, and G. Delnevo, "In-vehicle Human Machine Interface," in *Proceedings of the 2017 ACM Workshop on Interacting with Smart Objects*, Mar. 2017, pp. 7–12. doi: 10.1145/3038450.3038455.
[29] R. Ecker, P. Holzer, V. Broy, and A. Butz, "EcoChallenge: A race for efficiency," in *MobileHCI*, 2011, pp. 91–94.
[30] P. Bihler, D. Blumenau, S. Bendel, and S. Pilger, *Section I: proceedings of the IADIS International Conference Interfaces and Human Computer Interaction 2010 : section II: proceedings of the IADIS International Conference Game and Entertainment Technologies 2010 ; part of the IADIS Multi Conference on Computer Science and Information Systems 2010 ; Freiburg, Germany, July 26-30, 2010*. IADIS Press, 2010.
[31] V. C. Magaña and M. M. Organero, "The Impact of Using Gamification on the Eco-driving Learning," in *Advances in Intelligent*

Systems and Computing, vol. 291, Springer Verlag, 2014, pp. 45–52. doi: 10.1007/978-3-319-07596-9_5.

[32] M. Ćwil and W. Bartnik, "Supporting energy efficient train operation by using gamification to motivate train drivers," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 2018, vol. 10711 LNCS, pp. 239–253. doi: 10.1007/978-3-319-78795-4_17.

[33] C. Tselios *et al.*, "Enhancing an Eco-Driving Gamification Platform Through Wearable and Vehicle Sensor Data Integration," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 11912 LNCS, Springer, 2019, pp. 344–349. doi: 10.1007/978-3-030-34255-5_26.

[34] D. S. Tan, Bo. Begole, Wendy. Kellogg, and SIGCHI (Group : U.S.), *Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems : 2011 proceeding, Vancouver, BC, Canada - May 07-12, 2011*. ACM Press, 2011.

[35] S. Trösterer and P. Mörtl, "Motivating Drivers to Drive Energy Efficient," in *Future Interior Concepts*, Springer, Cham, 2021, pp. 71–87.

[36] A. Vaezipour, A. Rakotonirainy, and N. Haworth, "Design of a Gamified Interface to Improve Fuel Efficiency and Safe Driving," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 9747, Springer Verlag, 2016, pp. 322–332. doi: 10.1007/978-3-319-40355-7_31.

[37] T. Pace, S. Ramalingam, and D. Roedl, *CHI '07 Extended Abstracts on Human Factors in Computing Systems*. ACM, 2007.

[38] V. C. Magaña and M. M. Organero, "The impact of using gamification on the eco-driving learning," in *Advances in Intelligent Systems and Computing*, 2014, vol. 291, pp. 45–52. doi: 10.1007/978-3-319-07596-9_5.

[39] R. F. T. Brouwer, A. Stuiver, T. Hof, L. Kroon, J. Pauwelussen, and B. Holleman, "Personalised feedback and eco-driving: An explorative study," *Transp Res Part C Emerg Technol*, vol. 58, no. PD, pp. 760–771, Sep. 2015, doi: 10.1016/j.trc.2015.04.027.

[40] E. Wallius, A. C. T. Klock, and J. Hamari, "Playing it safe: A literature review and research agenda on motivational technologies in transportation safety," *Reliab Eng Syst Saf*, vol. 223, Jul. 2022, doi: 10.1016/j.ress.2022.108514.

[41] A. M. Toda *et al.*, "Analysing gamification elements in educational environments using an existing Gamification taxonomy," *Smart Learning Environments*, vol. 6, no. 1, Dec. 2019, doi: 10.1186/s40561-019-0106-1.

[42] M. Hofman-Bergholm, "Storytelling as an Educational Tool in Sustainable Education," *Sustainability (Switzerland)*, vol. 14, no. 5, Mar. 2022, doi: 10.3390/su14052946.