International Journal of Computer Information Systems and Industrial Management Applications
ISSN 2150-7988 Volume 16 (2024) pp. 485–501

Article

Gamification System for Eco-Driving: Enhancing Driver Motivation and Fuel Savings through Game Mechanics

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Received date: 5 April 2024; Accepted date: 21 June 2024; Published online: 10 July 2024

Abstract: Implementing a gamification system aims to motivate drivers to adopt eco-friendly driving behaviors and subsequently achieve fuel savings. The growing concern for environmental sustainability and the imperative to reduce carbon emissions from vehicular activities have led to increased interest in eco-driving practices. Gamification, which leverages elements from game design in non-game contexts, offers a promising avenue for fostering behavior change. This research presents a comprehensive framework for developing a gamification system that integrates game mechanics to encourage drivers to engage in fuel-efficient driving practices. This study employs a mixed-method approach that combines data collection from vehicle sensors and user feedback through user testing. The system's effectiveness regarding fuel savings and driving behavior modifications were evaluated by analyzing the data on driving habits and fuel consumption. The feedback from the participants provides insights into user engagement, motivational factors, and perceptions of the gamified eco-driving experience. Integrating real-time feedback and competitive elements resonates positively with users, stimulating sustained interest and participation. This study demonstrates the potential of gamification as an impactful tool for fostering eco-friendly behaviors and contributing to the broader goals of sustainable transportation and environmental preservation. This investigation contributes to gamification, eco-driving, and sustainable transportation by offering a tangible solution for encouraging positive behavior changes among drivers. The insights gained from this study provide a foundation for future endeavors to design effective gamification systems that address environmental concerns and promote sustainable practices in various domains.

Keywords: eco-driving; gamification; sustainable transportation; behavior change; fuel savings; game mechanics; carbon emissions; user engagement

1. Introduction

Advancements in technology have created a need to improve driver efficiency. Jointly with a logistics service provider in Portugal, it detains its "own distribution network with more than 500 vehicles and more than 1,200 employees spread across 21 operational platforms, which coordinate more than 8,500 deliveries daily" [1]. They demonstrate a keen interest in the matter, so they create an environment where they clarify the challenges and delineate areas where our assistance can be of value.

The importance of eco-driving in reducing carbon emissions is one of the topics that are primarily

approached in daily conversation [2] and is "relatively low-cost and immediate, and the improvement in fuel efficiency can be up to 45%" [3]. "The transport sector consumes about 20% of global energy and is responsible for nearly 25% of global energy-related carbon dioxide (CO_2) emissions, 75% of which are emitted by road transport" [3].

With the intervention of the European Union, they aimed to achieve a reduction of 55% in domestic greenhouse gas emissions by 2030 compared to 1990. Furthermore, their goal is to achieve climate neutrality by 2050 [4]. The central focus of this project is the impact on the transportation sector (see Figure 1).

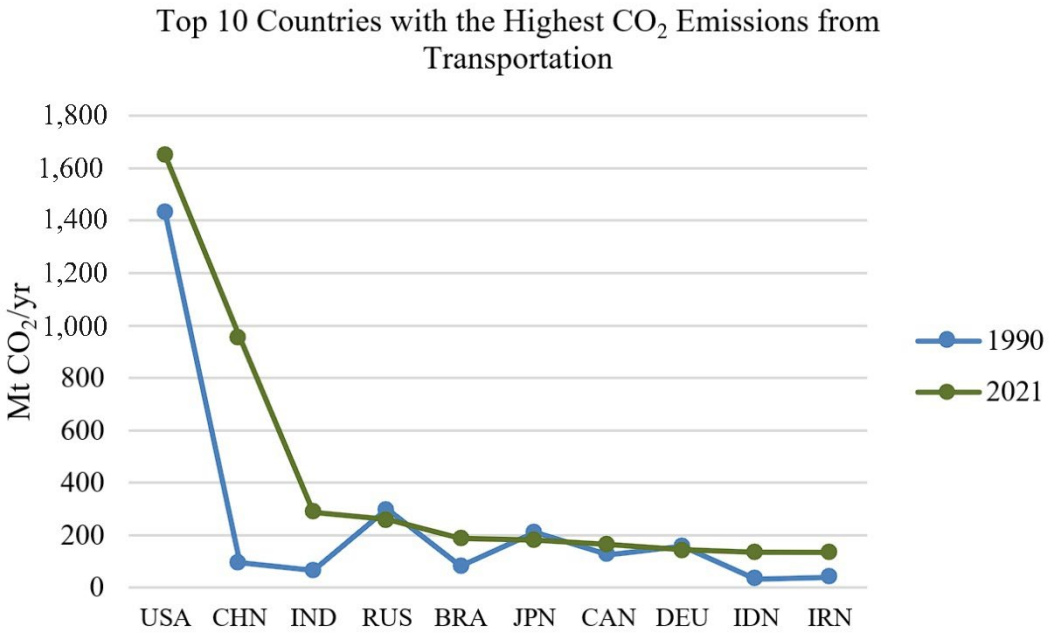

Figure 1. The Ranking of the Transportation Sector CO_2 Emissions produced annually by Country Top 10. Units: Values are expressed in Mt CO_2/yr. (megatons of carbon dioxide per year) [4].

"Driving behavior alone can have a large beneficial impact on fuel consumption." According to Lárusdóttir and Ulfarsson, the Clean Urban Transport for Europe (CUTE) project states that fuel usage is connected to vehicle average speed [5].

Other characteristics and situations that can also give rise to the expense are "driving behavior (or driving style), vehicle weight, pavement structure, pavement temperature, hybridization, and regenerative braking" [5].

Based on an analysis of data extracted from 67 diverse models spanning 1999 to 2002, weight affected this study. The results suggest that all vehicles experienced a 16% body weight decrease in fuel consumption. This finding emphasizes the importance of weight as a factor influencing fuel efficiency within the context of this analysis [5].

According to the data and analysis mentioned earlier, the company has identified that vehicles G7 and G8 consume fuel.

The fuel consumption that led to the spending on CO^2 emission originates with the "driving behavior but can also be influenced indirectly by several local measures, e.g., phased traffic lights" [6].

Truck drivers have a demanding occupation with constant, unrelenting pressure and tight schedules dictated by their superiors. These schedules are typically made with short deadlines. The pressure and responsibility that this profession requires are high and can be amplified when the drivers are transporting dangerous goods [7].

According to Google Trends, the term "Gamification" has become increasingly significant and widespread across industries since 2010 and remains relevant even today (explained in Figure 2).

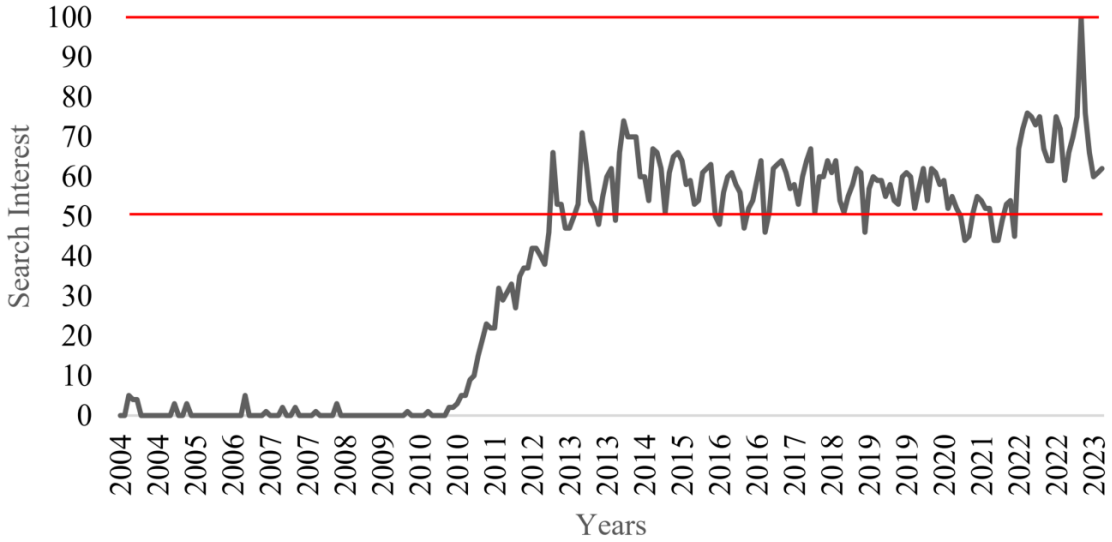

Figure 2. Search Interest at "Gamification". Source: Google Trends. Legend: "Numbers represent search interest relative to the highest point on the chart for the given region and time. A value of 100 is the peak popularity for the term. A value of 50 means that the term is half as popular. A score of 0 means there was not enough data for this term" [8].

According to Magana and Monuz-Organero [8], drivers should follow the advice that the "driver must not drive at high speed, avoid braking or accelerating sharply, avoid braking or accelerating unnecessarily, the user should drive at a steady speed and engine speed should be low." These recommendations should lead to a reduction in CO_2 emissions.

In addition, they added that a gamification system starts with a level of conformity with suggested driving advice, so the application will indicate what the users are as drivers and should do with the actual driving style to improve, which would be applied with a score [8].

Cooperatively with the company, they communicate that the problem is that drivers don't have access to information. They want to give them access to their consumption, braking, sudden acceleration, "*ralenti*" (i.e., when the vehicle is stationary but the engine remains operational), and any other relevant aspects that may impact the vehicle.

Investigative Goals

In collaboration with a company, the prevailing issue pertains to the lack of information accessibility among drivers. The objective was to provide drivers access to pertinent data. These aspects are significant because they can influence the vehicle's overall performance.

The primary objectives were to evaluate the existing gamification system in the company chosen, introduce a robust ranking mechanism, conduct comprehensive data analysis with an understanding of driving patterns, and establish an efficient information flow within the company.

These insightful observations contribute to the identification of strategies for enhancing efficiency and safety through data-driven decision-making.

A crucial aim is to establish and sustain a transparent mode of communication between drivers and stakeholders. This can be accomplished using a proficient gamification system for eco-driving.

2. Research Methodology

This research was conducted using the PRISMA methodology, Preferred Reporting Items for Systematic Reviews and Meta-Analyses" [9].

The search was conducted from October 2023 to January 2024, focusing on five years from 2019 to 2023. This limitation ensured that the state-of-the-art exclusively incorporated the latest studies conducted by the scientific community within this period.

2.1. Keyword Selection and Research Query

The following keywords were identified in relation to the selected topics:

- "Eco-driving" AND
- "Driving behaviour" OR "Drivers" AND

- “Gamification” AND
- “Fuel”

Multiple searches were conducted by combining the terms referred to above, such (as “Gamification” AND “Driving behavior” AND “Eco-driving”) AND (“Gamification” AND “Drivers” AND “Eco-driving” AND “Fuel”) specifically on the b-on website.

This selection was curated in the service, and where other limitations were added, such as Computer Science, Engineering, Information Technology, and Technology, and search within the full text of the articles and apply equivalent subjects. Likewise, the exploration was distinguished from incorporating the materials obtainable solely in English, “Academic Journals,” and “Full text”.

2.2. PRISMA Framework Findings

The PRISMA flow diagram encompasses four sequential stages: “Identification”, “Screening”, “Eligibility”, and “Included” and illustrates the execution of the query outlined in Section 2.1, explicitly focusing on the B-on repository. This query aligns with the "Identification" phase, serving as a systematic approach to pinpointing and retrieving relevant information from the B-on repository. An initial total of thirty-four articles and two theses were recommended for the first research.

After reading the information, the “Eligibility” phase remained at 15, and the Included phase remained at seven after reading all the information in the documents.

The selection process was based on the analysis of the documents. The first twenty-one documents were rejected from consideration due to their lack of relevance to the scope and focus of this research.

The selected abstracts were analyzed, and it was concluded that seven documents should be removed for the following reasons. These documents exclusively focus on the topics of bicycles, electric vehicles, self-driving cars, motorcycles, smart cities, and climatic conditions, and, in one case, only provide superficial information about cars. As these topics deviate from the central theme of the research, they were deemed less relevant and subsequently excluded. Figure 3 illustrates the study selection process using the PRISMA flow diagram.

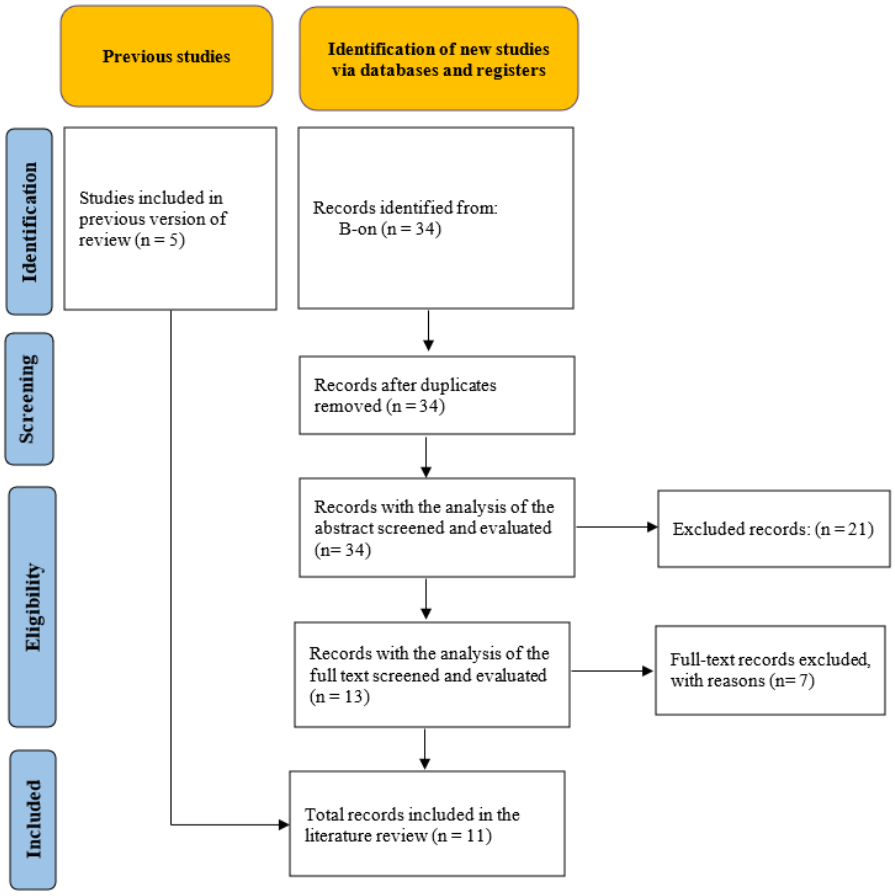

Figure 3. PRISMA flow diagram [9].

2.3. Identification of Journals

The detailed review included eight documents from Computer Science, Business, Engineering, and Social Science, covering two papers, four articles published in six publications, and two theses.

Among the journals observed, "Mobile Information Systems" appeared with the highest number of journals, contributing with two in the literature review. Interestingly, Elsevier Ltd. is the top publisher with the best quartile rank identification, as shown in Table 1.

Table 1. Main journals.

Academic Journal	Quartile Rank	Fields	Publisher
Mobile Information Systems	Q3	Computer Science	Hindawi Limited
Transportation Research Part F: Traffic Psychology and Behaviour	Q1	Engineering, Psychology; Social Sciences	Elsevier Ltd.
International Journal of Sustainable Transportation	Q1	Energy; Engineering; Environmental Science; and Social Sciences	Taylor & Francis Ltd.
Simulation and Gaming	Q2	Business, Management and Accounting; Computer Science and Social Sciences	Sage Journals
International journal of automotive and mechanical engineering	Q3	Automotive Engineering; Mechanical Engineering	The Automotive Engineering Centre (AEC), Universiti Malaysia Pahang
Sensors	Q2	Biochemistry, Genetics and Molecular Biology; Chemistry; Computer Science; Medicine; and Physics and Astronomy	Multidisciplinary Digital Publishing Institute (MDPI)
Sage Jornals	Q2	Arts and Humanities and Social Sciences	SAGE Publications Inc.
International Journal of Computer Information Systems and Industrial Management Applications	Q3	Business, Management and Accounting and Computer Science	-

2.4. Citation-Based Publication

In this section, the number of citations linked to every journal article the literature study includes is quantified and arranged in descending order. Citations are influential because they support arguments by binding them to the body of existing literature and demonstrating the argument's validity. Since the most recent publications are theses, they lack citations (see Table 2).

Table 2. Publications ranked by number of citations.

Title	Author	Year	Citations
Toward a Taxonomy Linking Game Attributes to Learning: An Empirical Study [10]	Bedwell, W. L., Pavlas, D., Heyne, K., Lazzara, E. H., & Salas, E.	2012	292
Average impact and essential features of onboard eco-driving feedback: A meta-analysis [11]	Sanguinetti, Angela, Queen, Ella, Yee, Christopher, Akanesuvan, Kantapon	2020	30
An Overview of Eco-Driving Theory, Capability Evaluation, and Training Applications [12]	Nan Xu, Xiaohan Li, Qiao Liu and Di Zhao	2021	11
Gamified Mobile Applications for Improving Driving Behavior: A Systematic Mapping Study [13]	Abderrahim El hafidy,Taoufik Rachad, ,Ali Idri and Ahmed Zellou	2021	7

Mobile Technology and Studies on Transport Behaviour: A Literature Analysis, Integrated Research Model, and Future Research Agenda [14]	Yan Sun, Chengi Liu	2021	3
A Playful Approach to Household Sustainability: Results from a Pilot Study on Resource Consumption [15]	Agusdinata, D.B., Lukosch, H., Hanif, M., Watkins, D.	2023	1
Review of Computational Techniques for Modelling Eco-Safe Driving Behaviour [16]	Neetika Jain and Sangeeta Mittal	2023	-
A pervasive app for a better management of energy and transportation [17]	Minh, Céline	2017	-
Gamification for public transportation - Improving attractiveness with interactive game elements [18]	Henrik Olofsson	2021	-
Gamework – A Framework Approach for Customizable Pervasive Applications [19]	Stach, Christoph	2011	-
Functions of Prototyping in the Context of Digital Games Research [20]	Werning, Stefan	2012	-

2.5. Visualization and Network Analysis Using VOSviewer

VOSview is a "software tool" that "offers text mining functionality that can be used to construct and visualise co-occurrence networks of important terms extracted from a body of scientific literature" [21].

2.6. Analysis of Keyword Frequency

The VOSviewer [21] identified 111 keywords, out of which only eight were ultimately selected because of the minimum number of occurrences (2). The Table 3 provides a visual representation of the occurrences' frequency and significance. The term "gamification" appeared with the highest frequency, totalling three occurrences, and a link strength of twenty-one, underscoring its importance.

Table 3. Keywords.

Keyword	Occurrences	Total Link strength
Gamification	3	5
Eco-driving	2	5
Fuel Economy	2	5
Fuels	2	5
Mobile application	2	4
Energy consumption	2	4
Machine learning	2	3
Mobile technology	1	3

In Figure 4, VOSViewer identified four distinct clusters in the image, each represented by a different colour: red and green.

Figure 4. VOSviewer clusters.

2.7. Eco-Driving and Gamification

Based on the thesis made by Minh Céline [17], she created an application that "collects and processes data regarding the user's travels and energy consumption" and developed "a smart decision support tool for house energy and transport usage" [17].

The main goal was to motivate users by highlighting how lifestyle changes can impact their health,

carbon footprint, and energy consumption. This was achieved by assessing the energy usage of the user's home and vehicles [17].

Initially, a workshop addressed several important topics, including UI design and the attractive vision of the application's interface. The goal was to "create awareness of energy consumption, such as carbon footprint reduction. Furthermore, it was investigated how to approach the rewards system where the physical reward is a must, and to users who accomplish substantial decreases in their emissions, for example, the "discount on an electric car, a free bus ticket or a lock for a bike" [17]. This project was made to operate in both real-time and historical data [17].

About data and carbon emissions, her objectives were that the app had to display information regarding the "approximation of the user's emissions and expenses due to the energy use at home and transportation during a day", "the number of km travelled by the user during a day" and "sensitize the user about the effect of gas emissions." The language of her choosing was Python for the backend calculations [17].

This approach to carbon emissions introduces a new perspective into the challenge of the gamification of eco-diving and adds a considerable layer of knowledge.

Another thesis that approaches gamification, however, is related to public transport, so Olofsson [18] analyzed and set out to investigate whether gamification can be successfully applied to the GoOn public transport app to increase user engagement and usage. This initiative resulted in a decrease in the use of public transportation during the pandemic.

It begins by addressing whether results can be achieved by implementing the application by adding game elements such as achievements, leaderboards, and other graphic components that can make the application experience more engaging and fun [18].

Regarding gamification, the Gamification framework can be described as [18], the initials GAME: "Gather—Gather information by asking questions. What are you gamifying? Who are your users? Why are you doing it? How do you measure your success?; Act—Act on the information you have. Designing the best solution for your goals and the engagement and experience of users. Then, it was tested with users; Measure—Measure user activity and goal outcomes. Obtain feedback and iterate improvements. Enrich—Enrich your system over time; people change, as do their goals. Keep up with them or one step ahead" [18].

The author stated that there are two main types of users: intrinsic and extrinsic. The former includes socializers (motivated by social interaction), free spirits (looking for opportunities and authenticity), achievers (overcoming personal challenges), and philanthropists (helping without expecting rewards). In contrast, the second type includes authors (contributing to rewards), consumers (looking for rewards for existing actions), connectors (looking for valuable contacts), and exploiters (finding loopholes in the system for personal gain) [18].

The gamification elements and system structure for developing the application involve a proof of concept, including levels and achievements, with objectives for the various levels and unlocking achievements based on users' actions. The author used tools such as ReactJS, which is a JavaScript library for developing the user interface, which was destined for the front-end; Amazon S3 was used, which is an Amazon cloud storage system Linux, to configure and run where the app would be hosted [18].

To gain a deeper understanding of the influence and improvement of transport-related behaviors, focusing on taking advantage of technology, especially mobile technology and data-based methodologies, this article [18] demonstrates how these technologies have impacted transport systems over the past two decades.

The method of collection of the information is by emphasizing GPS/GNSS data and telephone data [14], with CDRs and cell phone signals, and it should be noted that it has investigated sectors such as passenger transport, tourism, freight transport, and has also analyzed geographical locations and pervasive computing methods.

The authors stress the importance of "user-centric design" [14] and draw attention to the lack of approaches to design, consistency, and recognizability. They also discussed the need to understand the barriers and opportunities for successful application in the context of transportation.

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In the context of gamification, it is essential to note that [14] is similar to what is being proposed in this document, which recognizes the importance of improving driver behavior by reducing fuel consumption and carbon dioxide emissions. However, in [14], app gamification aimed to improve drivers' behavior and not mainly focus on eco-friendly decisions. The analysis highlights the data collection, for example, the driving speed, distance travelled, the number of hard stops, speeding, slowing down, and

sudden acceleration, and the driver's age, for example, the gender and location and if they existed more apps directed for health, it was essential to collect "the temperature and driver heartbeat, detection of fatigue, mood, sobriety, and stress level" [10].

About the app, the "most interesting functionalities in the selected mobile apps are geolocation, trip report/driving summary, registration/authentication, and profile creation", and it is crucial to combine "Points or scoring", "Levels or progress feedback", and "Socialization" elements" [10].
The rewards are a "way of recognizing users' efforts in accomplishing some tasks" and "can be presented in the form of a service discount, gifts, or monetary" [10].

Designing effective interfaces for eco-feedback is crucial for encouraging sustainable behavior. Feedback capturing both instantaneous and accumulated actions is more impactful [11].

The potential of gamification is to promote behavioral change; in [15], serious games can raise awareness and influence behavior regarding the consumption of domestic resources. Emphasizing behavior change is reflected in the game's effectiveness, thus increasing the efficacy and safety of decision-making.

The results of this study [11] observe that the meta-analysis estimates that "eco-driving feedback can be expected to result in an average of 6.6% improvement in fuel economy". The change in driver behavior derived from the fuel economy directly impacts on-board feedback on the fuel economy [11].

According to Rule-Based Eco-Driving Theory [12] which focuses on real-world, experience-based driving behaviors, four driving modes are considered: idling, cruising, accelerating, and deceleration. Minh Celine's thesis demonstrates that algorithms for optimal vehicle control based on models and real-time data are used in optimization-based eco-driving (Figure 5).

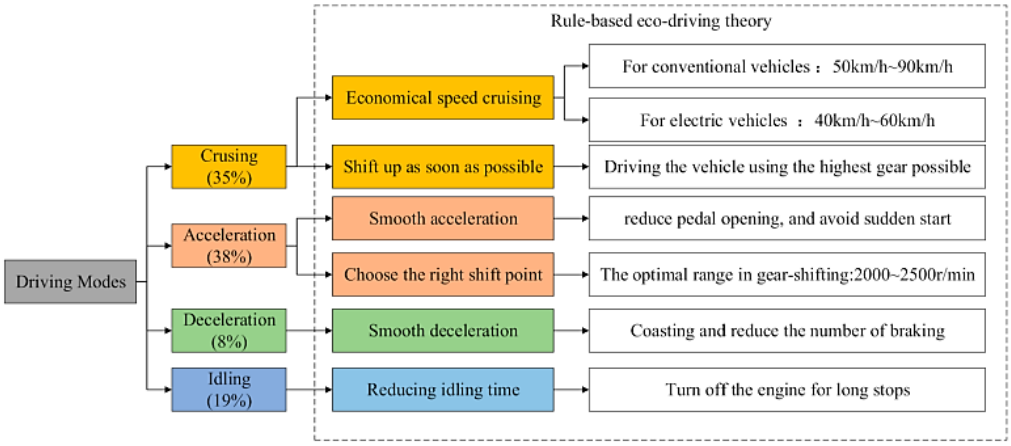

Figure 5. Rule-based eco-driving theory in the main driving modes [12].

Bedwell claims that control is a crucial component of the analysis because it gives drivers authority over their behaviour and makes monitoring their progress towards environmentally friendly objectives easier, increasing motivation and engagement. The human interaction is a "networked game that provides voice chat and has a supervisor giving support vs. a game that isolates the player from all other human contact" [10].

This thesis [18] revolves around the gamification theme, and "Gamework" offers resources for designing mobile games that incorporate these components. Using "Gamework", developers can design interactive experiences that track players' progress, provide challenges, and inspire players.

Similar behavioral incentives can be used by mobile game developers to create challenges that imitate eco-friendly driving situations, paying players to choose actions that protect the environment. The feedback is crucial, as it refers to how players in virtual worlds perceive the repercussions of their decisions, the games created, and how the "Gamework" can build greater environmental consciousness and drive action outside the gaming setting [19].

According to Werning, the goal is to create systems or experiences that favorably affect user behavior by prototyping, enabling the investigation of various techniques to achieve this aim, consistent with the iterative design process used in creating gamification systems [20].

The research on using gamification to encourage environmentally conscious behavior in sectors like energy and transportation, user-centric design [14]—which recognizes that overcoming obstacles is essential to creating successful transportation apps—and gamification components, such as interfaces and incentives, are the main points of contention.

Furthermore, studies on the effects of serious games on fuel economy and the optimization of fuel consumption through machine learning techniques contribute to a comprehensive understanding of behavior change in energy-related domains. This is because serious games also play a significant role in promoting sustainable behavior.

Within the themes of gamification, eco-driving, and energy consumption awareness, what has been mentioned can contribute to an improved comprehension of how technology, data-based approaches, and gamification have positively impacted future user conduct, leading to the promotion of sustainability in vehicles.

3. Developing Eco-Driving Game

To encourage the approach to achieving the benefits of eco-driving and reducing the environmental impact of vehicular activities by developing a gamification system, which appears to be a promising alternative for behavioral transformation.

The game aims to delve into the theoretical foundation of an eco-driving gamification system directly connected to transportation. These objectives are resourceful and multifaceted (explained in Figure 6). The work of Minh Céline [17] says that she developed an application whose primary purpose is to motivate users and improve their lifestyle; this point of view can connect with the company's angle transmitted by helping drivers gain motivation through rewards and as they make better choices as drivers.

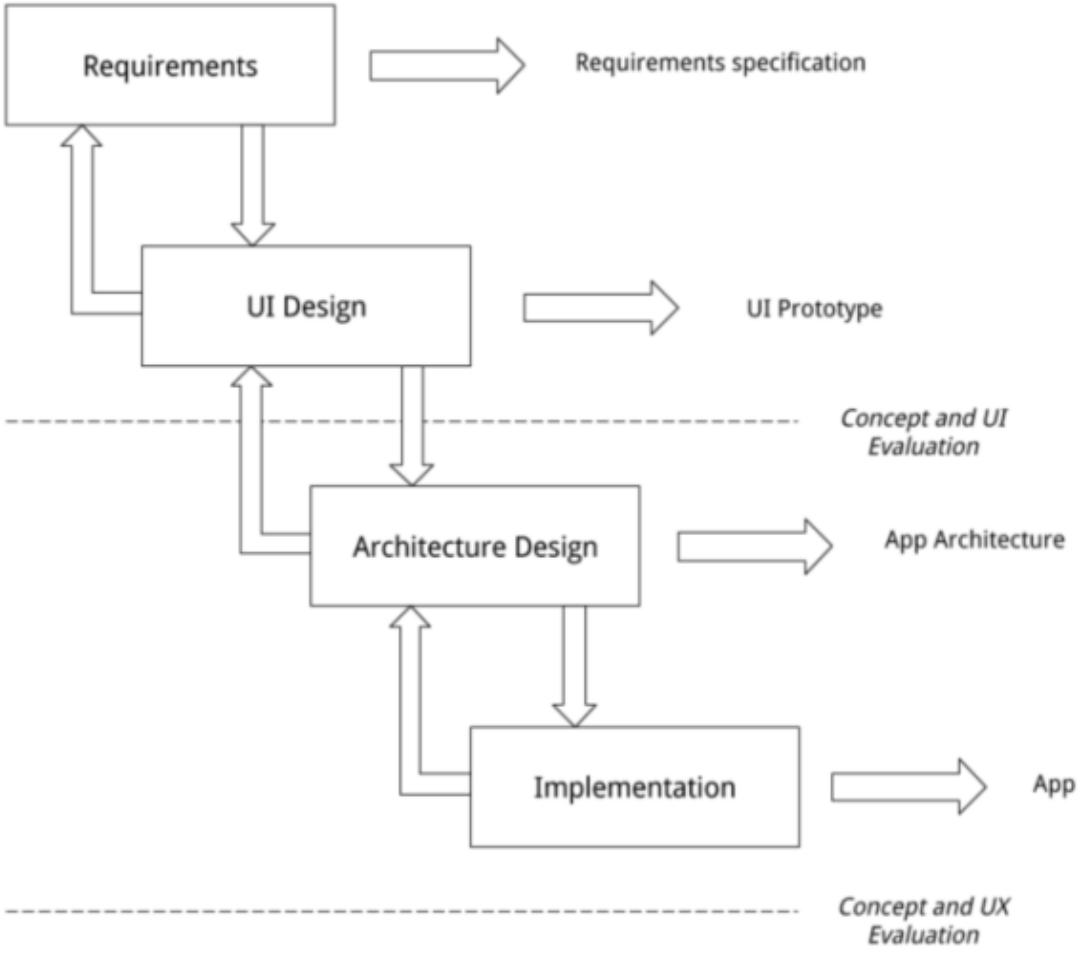

Figure 6. Development process [17].

Also, Minh Céline [17] emphasizes the connotation that the historical data in real-time can create an impact by allowing the users to understand their emissions and expenses. This is a worthy initiative that can help the company drivers gain motivation so they can improve daily. This approach can increase the number of users by fostering more eco-conscious behavior.

The mechanics of the gamification system are a crucial part of future changes in behavior; the essential elements are points, badges, leaderboards, challenges, and rewards, which are integrated into the system. As Olofsson highlights in this work, it is by finding information about the power of the

elements. His research with conquerors and classifications led to increased user involvement, making the driver's experience more engaging and evolutionary for themselves.

The design principles that make the system whole are fundamental, like creating an interface and functionalities that can relate to the users and make them adopt more eco-driving habits. Olofsson [18] introduced the structure "GAME", which highlights the importance of collecting information, tracking the user's activity, and continuously enriching the system so it can align with the user's objectives. This analysis of the users illuminates the possibilities of motivation for them to be involved in the gamification elements since social interaction and personal fulfilment. This can lead to the different variety of the users that drive the vehicles and how we can understand them on a deeper level.

This framework acts as a bridge between the theoretical and practical to highlight the details that lead to a critical initiative on the part of the components so that they can be motivated to adopt more ecological behaviors as drivers and that this results in a reduction in fuel consumption and its respective environmental impact—proposing introducing a gamification system in logistics firms to encourage sustainable fuel consumption among vehicle drivers. The gamification system proposal intends to utilize game aspects like points, incentives, levels, and challenges to encourage staff to embrace sustainable practices. The Game will rely on three primary pillars:

1. **Information**: Offer drivers information about the advantages of sustainability and guidance on incorporating more sustainable practices into their regular routines.
2. **Players**: Incentives to drivers for implementing sustainable practices. The rewards can be tangible, like discount vouchers or prizes, or intangible, like public recognition or opportunities for career growth.
3. **Improvements**: Promote competitiveness among employees and collaboration among teams. This will foster a competitive and motivating work environment, as well as encourage the sharing of best practices.

3.1. Information and Data Sharing

Empirical and individual data on each driver is required to gather information on the driving behavior of logistics firm drivers. The sensing and telemetry equipment installed in each car being studied will be used for this purpose. Telemetry systems collect data on fuel use in lorries by utilizing communication systems like the vehicle's Common User Network Bus (CANBUS) to extract information. This system, commonly seen in trucks, links electronic and computer parts to communicate between various systems like the engine, brakes, and gearbox. CANBUS is a bidirectional network that allows both the transmission and reception of information, which is crucial for truck coordination, performance, safety, and efficiency.

The Telemetry system serves as a sophisticated monitoring solution in this project, delivering specific information on the position and status of the vehicles' systems and sensors. This involves monitoring location through the Global Positioning System (GPS), tracking fuel use, and other significant factors. The data produced by the Telemetry devices is collected over an API and saved immediately to ensure accuracy and promptness. This approach guarantees that all pertinent information is documented and promptly accessible for examination and dissemination.

Every driver is given an individual identifier connected to the telemetry system. The identifier may be a driver company's individual index (ID) or a unique login linked to the driver. The telemetry data is tagged with the drivers identified to link each data point with the respective driver. Over time, the accumulated telemetry data creates an extensive record for every driver. The data generates personalized driving profiles that describe each driver's driving behavior, habits, and performance. The driving profiles consist of the following parameters:

- Fuel efficiency.
- Changes in velocity.
- Acceleration and deceleration behavior.
- Engine revolutions per minute.
- Time spent idling.
- GPS locations.

Advanced analytics techniques are used on the telemetry data to extract insights and patterns from the driving behaviour of individual drivers. This analysis entails discovering patterns, irregularities, and opportunities to enhance driving behaviour. Connecting the truck telemetry system with the driver's construction of driving profiles allows fleet managers to obtain valuable insights into each driver's driving behavior, encourage safer and more fuel-efficient driving habits, and improve the fleet's overall performance.

3.2. Rules and Game Mechanics

The rules and game mechanics play essential roles in using gamification to promote eco-driving among truck drivers. The rules and game mechanics are established to offer organization and direction for drivers engaging in the eco-driving gamification system. Guarantee equitable conduct and deter fraudulent behavior or misuse of the system: Emphasize safety and conscientious driving conduct. Promote transparency and trust in the scoring and evaluation process. Incentivize drivers to actively participate in the game and work towards enhancing their eco-driving abilities. Promote competition among drivers by implementing leaderboards and scoring systems and provide feedback, coaching, and incentives to assist drivers in their eco-driving endeavors. Facilitate progress monitoring and display accomplishments chronologically, creating a feeling of community and teamwork among drivers by incorporating social elements and interactions, promoting eco-conscious driving practices and decreasing fuel usage in the fleet.

Tables 4 and 5 display the mechanics and rules necessary for the game to function. The designs are straightforward to facilitate rapid implementation and comprehension by the drivers and the subjects under analysis. The tables display the names and goals of each.

Table 4. Game mechanics.

Mechanics	Description
Score Calculation	The scoring system will assess various driving behaviors using telemetry data from the truck's CANBUS system. Key metrics include speed consistency, acceleration and braking patterns, idling time, and adherence to eco-driving principles.
Leaderboards	A leaderboard will display daily and weekly rankings of drivers based on their scores. This fosters competition and encourages drivers to improve their rankings over time.
Achievements and Rewards	Drivers can earn achievements for reaching milestones or demonstrating exceptional eco-driving skills. These achievements unlock rewards such as in-app badges or tangible incentives like gift cards.
Feedback and Coaching	The game will provide real-time feedback on driving performance, highlighting areas for improvement and offering personalized coaching tips. This feedback loop is essential for continuous skill development.
Progress Tracking	A dashboard will allow drivers to track their progress over time, visualizing their improvement in eco-driving skills and fuel efficiency.

Table 5. Games Rules.

Rules	Goals
Speed Limit Adherence	Drivers must adhere to posted speed limits and maintain a consistent speed whenever possible. Excessive speeding will result in point deductions.
Smooth Acceleration and Braking	Sudden accelerations and harsh braking should be minimized to conserve fuel and reduce wear and tear on the vehicle.
Minimize Idling	Drivers should avoid unnecessary idling by turning off the engine when parked or waiting for extended periods.
Route Optimization	Drivers are encouraged to plan their routes efficiently to minimize mileage and fuel consumption.
Safety First	While eco-driving is encouraged, safety remains the top priority. Drivers must always prioritize safe driving practices, including following traffic laws and maintaining proper vehicle control.
Continuous Improvement	Drivers should actively seek to improve their eco-driving skills by following feedback and coaching provided by the game.

The scoring system is crucial for fostering competitiveness. Scoring is determined by daily performance as well as the total performance over a week, month, and year. The game either rewards or penalizes drivers according to their performance. The score is based on adherence to the set metrics, fostering a competitive atmosphere that motivates ongoing enhancement, as indicated in Table 6.

Table 6. Points System.

Category	Metrics	Unit	Points
Acceleration Profile	Rough acceleration	In 1000 Km	–15
	Undue acceleration	In 1000 Km	–10
	Average accelerator pedal depth	In 1000 Km	10
Cruise Control Profile	Speed	In 100 Km	15
	Using cruise control	In 100 Km	10
	Kilometres travelled with cruise control active/inactive	%/seconds	10
Engine Profile	Engine revs in Green zone	%/seconds	20
	Engine revs in Red zone	%/seconds	–20
	Relationship between pedal depth and revolutions	%/seconds	20
Harnessing Inertia	Time in inertia / Ecoroll	%/seconds	10
Ralenti Times	Total *Ralenti*	%/seconds	10
Consumption	Media Consumption	In 100 Km	25

3.3. Improvements/changes/feedback

An interactive procedure will be implemented to continuously collect and analyze feedback from drivers and other game users to improve and repair errors. Regular general questionnaires will be conducted to understand the motivations and improvements of drivers, who are this gamification system's primary users and benefactors. Functionalities and settings are adjusted based on feedback, incorporating highly valued rewards and variables that promote behavior modification. We create a reward system subject to testing and modification through ongoing input to guarantee that the prizes are appealing and the responsibilities are equitable:

- **Compulsory Training:** Drivers who do not achieve goals may need to undergo supplementary eco-driving training.
- **Performance Review:** Regular feedback sessions with supervisors to discuss and identify improvement areas.
- **Alerts and Reminders:** A notification system prompts drivers about daily eco-driving practices.

Balance and effectiveness are crucial in the gamification system for drivers. The gamification system balances rewards and incentives with clear obligations and opportunities for improvement. It is recognized and rewarded high performers while creating an environment where all drivers can grow, improve, and contribute significantly to the company's goals.

3.4. Mobile Application Layout

The purpose of developing this mobile application (APP) is to provide drivers with a user-friendly and intuitive platform to access the game, view their driving data, and track individual performance metrics. The APP is a vital strategic choice to address operational obstacles by enhancing efficiency and sustainability. It is designed with a clean and easy interface to simplify complexity and information overload, making it accessible to users of all technical levels. It is emphasizing security and adhering to data privacy and security regulations. This comprehensive solution will enhance access to critical information and promote a knowledgeable, adaptable, and enduring operational environment.

The APP can potentially drive a cultural shift in driver's behavior by promoting information sharing, eco-friendly driving practices, and enhancing interaction between company management and drivers to improve sustainability and reduce fuel consumption. Figures 7 and 8 display the planned designs for the APP, which dictate how specific information is visualized for each employee, categorizing the data based on their active score and ranking.

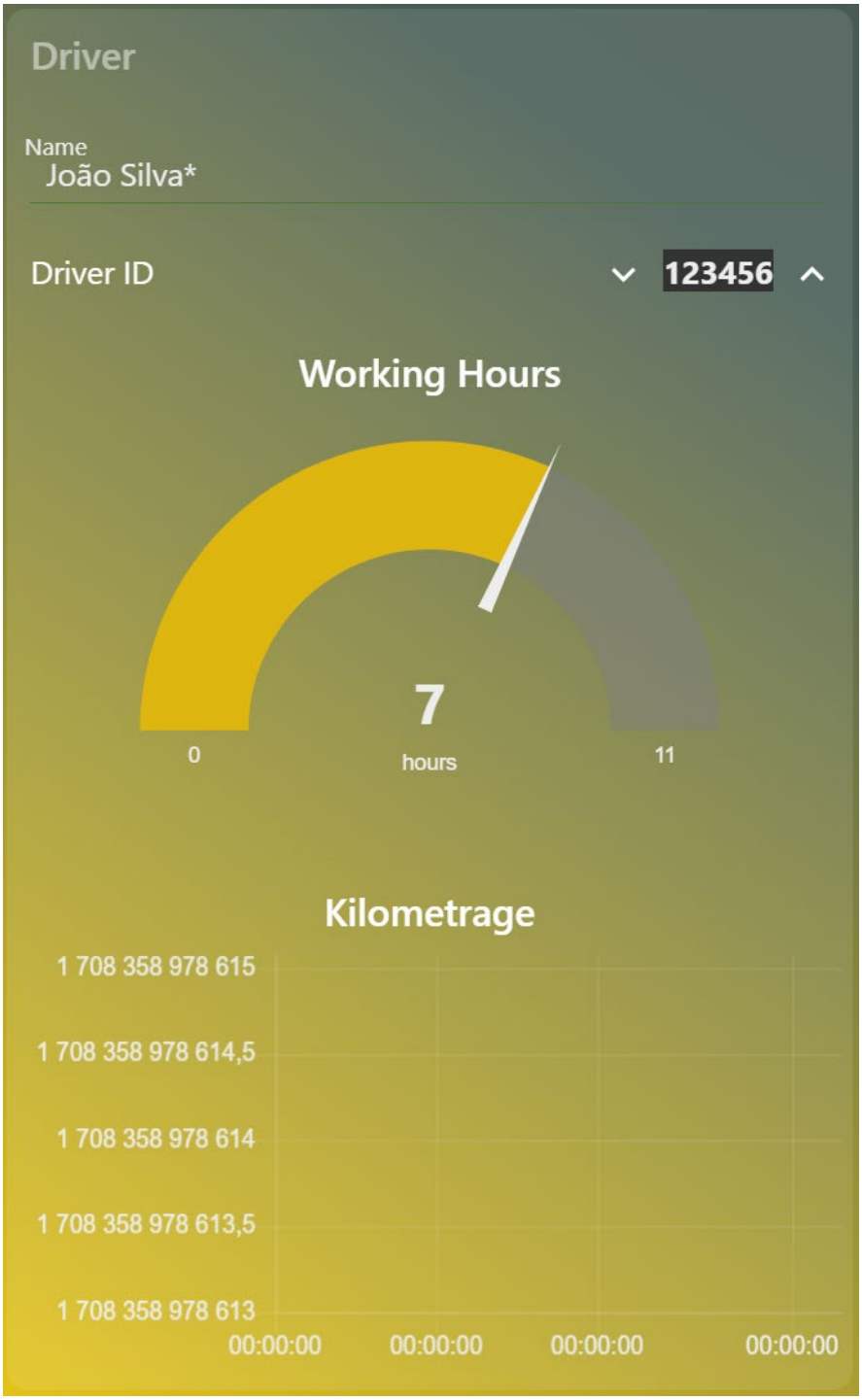

Figure 7. Driver Information.

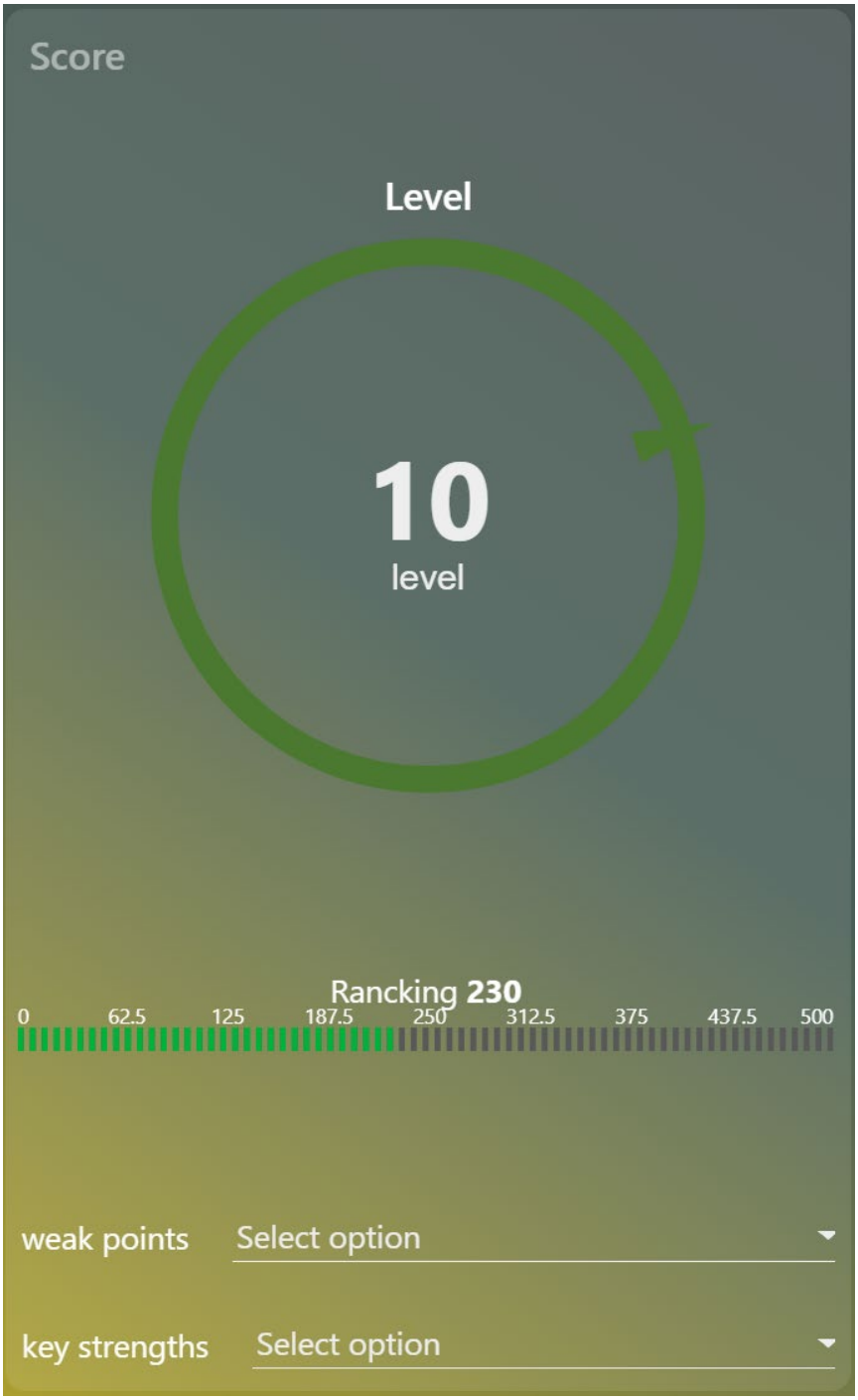

Figure 8. Driver Score.

Figure 9 displays the driver's score based on a specific measurement characteristic, providing insights into their driving performance and highlighting areas for improvement to increase efficiency, reduce fuel consumption, and maintain productivity.

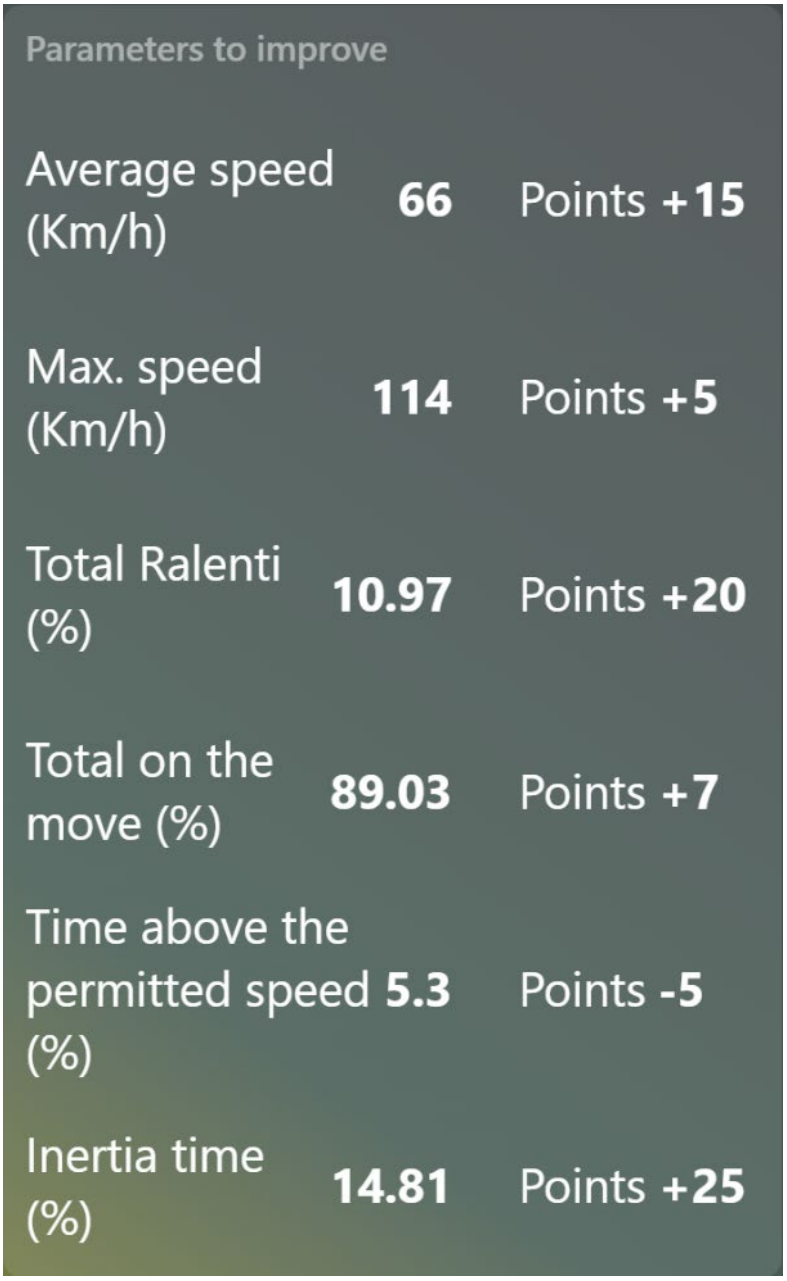

Figure 9. Parameters Points.

5. Conclusions

Concluding, implementing a gamification system designed to incentivize drivers to embrace environmentally conscious driving habits constitutes a noteworthy advancement in tackling the urgent issues surrounding ecological sustainability and curtailing carbon emissions from automotive operations. The results of this study have shed light on the potential of gamification, which involves incorporating game design elements into non-game settings as a potent driver of behavior modification.

By employing a rigorous mixed-methods methodology, which incorporates collecting data from vehicle sensors and acquiring valuable user feedback through user testing, we will formulate a comprehensive framework for creating a proficient gamification system. The system will incorporate various game mechanics, such as challenges, rewards, leaderboards, and progress tracking, to motivate and incentivize drivers to actively participate in fuel-efficient driving practices.

The discernible effect of implementing this gamification system on driver behavior is apparent, as there is a noticeable decrease in fuel consumption and an increased inclination to adopt environmentally conscious driving techniques. The integration of real-time feedback and competitive elements has been well received by users, resulting in the cultivation of enduring interest and active engagement.

This study highlights the potential of gamification as a dynamic tool for promoting eco-friendly behaviors

and aligns with the broader goals of sustainable transportation and environmental conservation. This intervention provides a tangible resolution to promote favorable modifications in driver behavior, making a substantial contribution to gamification, eco-driving, and sustainable transportation.
Implementing gamification in the context of eco-driving practices holds significant potential for fostering a sustainable and environmentally aware future within transportation.

Author Contributions
Conceptualization, A.F., D.C. and J.R.; formal analysis, A.F.; investigation, A.F. and D.C.; methodology, A.F.; data curation, D.C. and J.R.; supervision D.C. and J.C.F.; visualization D.C.; writing—original draft, A.F.; and writing—review and editing, A.F., D.C. and J.C.F. All authors have read and agreed to the published version of the manuscript.

Funding
This work was supported by the project 'BLOCKCHAIN.PT (RE-C05-i01.01-Agendas/Alianças Mobilizadoras para a Reindustrialização, Plano de Recuperação e Resiliência de Portugal na sua componente 5-Capitalização e Inovação Empresarial e com o Regulamento do Sistema de Incentivos "Agendas para a Inovação Empresarial", approved by Ministerial Order No. 43-A/2022 of 19.01.2022).

Conflict of Interest Statement
The authors declare no conflict of interest.

Data Availability Statement
Not Applicable.

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