Universiteit Utrecht

FleetNexis: Integrating Gamification and Intrinsic Motivation Strategies to Foster Long-Lasting Eco-Friendly Behaviors for Commercial Drivers

Within the WorkUp Application for Bridgestone Mobility Solutions

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1 Abstract

This study presents the development and evaluation in the form of interviews of a gamified prototype aimed at fostering long-term eco-driving behaviors among fleet drivers. To promote environmentally friendly driving practices and lower fuel usage, the prototype is built on four pillars such as personalised driver profiles, mission-based tasks, feedback, and community involvement. Five in-depth interviews with managers and people in the industry exposed both strengths and areas for improvement. Although personalised interventions and intrinsic motivation were shown to have the potential to work effectively for certain drivers, all interviewees indicated that drivers needed extrinsic incentives, such as vouchers, to sustain long-term commitment. Moreover, while being a crucial element of the strategy, feedback system needs further development to minimise information overload and increase accessibility for users.

This study serves as a catalyst for future efforts to improve the prototype, aligning it more closely with driver needs and testing it directly in real-world environments. From a technical perspective, the next phase is putting the prototype in code, evaluating its viability, and investigating possible limitations in real-time data processing and feedback integration. In the long term, the prototype has the potential to develop into a system that fosters both short-term engagement and long-term sustainable behaviour change.

2 Introduction

Sustainable and environmentally friendly transportation options are becoming more and more important in the modern society; with the commercial trucking sector not being an exception [1]. The need of competent truck drivers in implementing eco-friendly and safe driving habits is of great relevance given growing need for efficient and ecologically friendly freight transportation [2]. The present difficulty is that many drivers lack the necessary drive to adopt sustainable driving practices even when they have access to modern technologies. This lack of motivation among drivers emphasises the need of methods transcending simple technical answers [3].

Although vehicle designs have been altered to improve fuel efficiency and decrease emissions, the actual achievement of these benefits relies on drivers' dedication to environmentally friendly behaviours. Industry pioneers are continuously searching for groundbreaking ideas to improve the safety, sustainability, and efficiency of commercial transportation operations. This desire drives a mission to look at fresh ideas that can change how professional truck, and not only, drivers approach their work [4]. Among such creative ideas under examination is gamification [5].

Gamification is a dynamic technique seeking to adapt the ideas of game design, such as competition, incentives, and engagement, and apply them to real-life settings [6]. It transforms the routine chore of driving into an exciting experience where every environmentally beneficial behaviour becomes a personal victory. This reinterpretation of daily chores via the prism of play has attracted a lot of attention, and positions gamification as a potential transportation industry catalyst [7].

The commercial trucking industry has a significant environmental footprint, making a big contribution to global carbon dioxide emissions. The industry is a significant user of fossil fuels and contributes to the release of greenhouse gases, which in turn contribute to air pollution and climate change [8]. The trucking industry's need to embrace more sustainable practices is becoming more important as public awareness of environmental issues grows and regulatory constraints get stricter [1].

Although there are existing technological solutions, it is still a present challenge to get drivers to adopt sustainable driving practices. Long-term behaviour modification is challenging when relying on conventional approaches of motivation such as financial incentives or regulatory compliance. Long-distance trucking's monotonous character can cause driver disengagement, which makes it challenging to keep attention on environmentally friendly driving methods over long stretches [3]. Even with training courses in place, without constant reinforcement and motivation, eco-driving practices may be lost rather quickly. This emphasises the need of creative ideas that can efficiently include drivers and promote a stronger will to use sustainable driving methods. In light of this, gamification inspires drivers by including points, badges, and leaderboards, with the aim of fostering competitiveness and success. This not only makes driving more fun but also motivates drivers to keep raising their eco-driving performance. Gamification systems' instantaneous feedback lets drivers see the effects of their actions in real time, therefore supporting positive behaviour and continuous involvement [7].

Nevertheless, gamification alone has a tendency to be ephemeral and tends to not maintain enduring modifications in behaviour over time. In order to achieve long-term behaviour adjustment, drivers must deeply and consciously develop their intrinsic motivation [9]. Intrinsic motivation is the internal drive to engage in an action for its own sake, rather than being driven by external rewards. Encouragement of personal satisfaction and pride in environmentally responsible driving helps to make sustainable activities a natural component of the drivers' professional identity [10].

In this thesis, the integration of gamification into professional truck driving is explored through Bridgestone Mobility Solutions' Webfleet WorkUp application. The proposed strategy aims to modify the mindset of professional truck drivers towards their driving practices and the subsequent environmental consequences. The

WorkUp app's strategy prioritises the drivers' own beliefs and goals related to environmental responsibility and professional expertise, in addition to offering outside motivators such as points and medals. The inclusion of gamification elements, such as leaderboards that track community performance, points, medals, and badges, may foster a competitive and supportive atmosphere that motivates drivers to enhance their performance. Due to also utilising intrinsic motivational strategies such as personalised driver profiles and missions, this method offers a comprehensive strategy for promoting enduring and sustainable driving behaviours. The goal of this thesis is to test whether a combined approach prototype can motivate drivers to internalize these behaviors as part of their self-concept, thereby generating long-lasting change.

This approach can be included into professional driving for eco-friendly driving purposes beyond WorkUp. Growing amounts of studies and pragmatic projects investigating the wider possibilities of gamification to improve the sustainability of the transportation industry are under progress. Along with the investigation of new technologies including augmented reality and virtual reality to produce immersive training experiences [4]. This includes the development of thorough gamification frameworks that can be customised for various operational settings and driver needs.

3 Gamification

Duolingo [11], a language-learning application employing diverse game-like elements to motivate users, is one of the most prominent examples of gamification. *Duolingo* engages the competitive nature of users and encourages consistent participation with the integration of streak counts, experience points (XP), rewards, and leaderboards. *Duolingo*'s method plays with the psychology of habit building. Daily reminders to finish language courses help users to keep their streak alive; the app's ranking system lets them compare their development with friends or other students. *Duolingo* also gives students XP for finishing courses and practicing languages, therefore providing a real sense of development. The successful implementation of gamification tactics is dependent on this type of use of positive reinforcement, which promotes the sense of fulfilment and gratification that come with task completion, hence boosting intrinsic motivation [12].

Gamification has also been extensively utilised by corporations to improve employee professional development and performance management. Salesforce, a prominent provider of Customer Relationship Management software, has introduced *Trailhead* [13], an online learning tool that features gamified learning objectives. The tool is designed to instruct users on how to use Salesforce's products. *Trailhead* enables users to accumulate badges, points, and certifications as they complete courses. Through providing leaderboards, the system encourages employees to surpass their colleagues, thus improving productivity and morale. It also promotes a culture of learning and success inside companies. Including gamification into such systems has demonstrated how the same psychological ideas that make games addicting can be applied to increase learning results and job involvement [14].

Gamification has also been used within the wellness and healthcare sector. *Strava* [15] application uses gamified components to motivate people towards an active and healthy life. Completing challenges and tracking exercises generates personal records and badges that provide recognition for reaching milestones and serve as motivation for continuous engagement. Leaderboards and community features in the application's social component help to foster accountability and friendly competition amongst the users. Regular feedback allows users to see tangible evidence of their development, which motivates them to keep working out. This is a classic application of gamification's potential to drive healthier behavior change and habit formation through communal and reward-based motivations. Studies have shown that gamified interventions in health applications can lead to improved user retention and health outcomes because they make the task of staying fit more engaging and enjoyable [16].

Furthermore, gamification has gained success in the educational field as it increases student participation and yields better learning outcomes. One great example is *Kahoot!* [17], a tool for schools creating quiz-based games. Turning education into a competitive and engaging experience helps *Kahoot!* increase students' enthusiasm for participating in classes. Time limits, points, and leaderboards help users to act fast and aim for higher performance. Furthermore, *Kahoot!* provides instantaneous feedback so that students can immediately see the results of their behaviour, which helps in reinforcing learning [18]. This strategy is effective as it helps students to stay motivated over time by making learning seem more like an enjoyable activity than a drudgery.

Gamification techniques have also greatly helped programs in marketing and client loyalty. *Starbucks*, for example, employs gamification through its rewards program to inspire customer loyalty. Every purchase earns stars for customers, which build up to access freebies or discounts. The system replics gaming dynamics whereby the user strives towards a goal, that is to accumulates enough stars to merit a reward. Additionally incorporated are frequent challenges, sometimes known as quests, which motivate consumers to purchase more within a given timeframe to maximise benefits. The gamified loyalty program motivates customers to keep returning by creating an accomplishment and advancement sense, therefore enhancing client retention [19]. These programs' benefits make use of extrinsic motivation where customers are driven to engage with the brand not just for the product but also for the rewards and recognition they receive.

While gamification offers considerable potential across various fields, there are key considerations to keep in mind. Poorly designed gamification systems can result in frustration and boredom, therefore leading to disengagement. Users might disengage if the benefits appear insignificant or unreachable. Furthermore, an over-reliance on extrinsic incentives can diminish intrinsic motivation, especially if individuals prioritise collecting rewards over deriving satisfaction from the work itself [20]. Therefore, the key to successful gamification is to achieve a balance between internal and extrinsic motivators while ensuring that the gamified elements align with the users' objectives and interests.

When used deliberately and deftly, gamification has the power to change people's interaction with regular chores. Including gaming elements into non-game environments helps to make otherwise boring events interesting and fun. As presented here, gamification has shown to be a flexible and powerful tool whether it's pushing staff members to upskill, driving students to learn, or enabling people to keep fit. Gamification is altering the way we approach participation and behaviour change, from sites like Duolingo and Salesforce Trail to health apps like Strava and educational tools like Kahoot!. However, like with any approach, it should be utilised with caution to ensure that it complements rather than detracts from the user's or company's primary aims.

4 OptiDrive

By integrating cutting-edge technologies like OptiDrive 360, Bridgestone Mobility Solutions' Webfleet system is transforming fleet management by improving efficiency and sustainability in commercial transportation [21]. OptiDrive 360, in tandem with LINK 640/740 devices, communicates with a vehicle's internal systems, including CANBus (Controller Area Network) for communication among several components [22] and OBD (On-Board Diagnostics), for analysing the operation of major engine components [23]. Depending on the data needs of the fleet, other devices like the LCS 100 (LINK CAN Sensor 100) or FMS (Fleet Management System) [24] can be used to get more detailed information. The LCS 100 and FMS give the acquisition of data that would be inaccessible by CANBus or OBD, hence offering advanced understanding of vehicle performance. The PRO Driver Terminal, while not essential for producing performance statistics, serves to provide data to the driver and oversee daily operations [25].

Webfleet enables fleet managers to monitor real-time vehicle information and optimise operations. This feature is very efficient for monitoring driver behaviour in diverse settings, ensuring the ability to enhance fuel efficiency in all scenarios. Webfleet emphasises driver safety by monitoring acceleration, braking, speed and other metrics, thereby equipping management with valuable insights to reduce vehicle wear, lower maintenance expenses, and underline safety. Ultimately, Bridgestone Mobility Solutions' Webfleet, in tandem with OptiDrive 360, offers a holistic solution that enhances efficiency, sustainability, and safety in commercial fleet operations.

5 Motivation

Encouraging truck drivers to regularly use safe and environmentally friendly driving techniques has proven to still be challenging [26]. Conventional methods often depend on extrinsic motivators, such monetary incentives, which provide temporary gains but do not always encourage natural commitment to environmentally friendly activities [1]. Consequently, there is a significant knowledge vacuum on how to properly inspire truck drivers in a way that they absorb and apply safe and environmentally beneficial driving techniques into their daily lives.

Approaches meant to solve this issue have mostly concentrated on two fronts: driver training programs [27] and technology developments in vehicle design and management solutions. Incorporating aerodynamic designs [28], advanced engine technologies [29], and improved fuel management systems [30], vehicle manufacturers have made tremendous progress in building fuel-efficient and environmentally friendly trucks. Although these developments greatly help to lower emissions, they do not directly address the motivating factors of drivers' behaviour.

Conversely, driver training courses have aimed to teach truck drivers about environmentally friendly driving techniques and safety precautions [2]. Although classroom instruction, simulators, and regular assessments [4] are often included, these initiatives do not provide ongoing motivation and involvement outside of the first training cycle. It seems impossible to overestimate the part gamification plays in inspiring such natural drive; it turns the boring daily grind of driving into an exciting experience whereby every environmentally responsible action supports a larger story of personal success and environmental preservation. This study attempts to contribute to sustainable commercial transport solutions by interlacing the motivating framework of gamification with the intrinsically driven features of environmentally responsible truck driving.

Although conventional driver training courses have been very important in teaching truck drivers about environmentally friendly driving techniques and safety precautions, the introduction of information technology-enhanced solutions has created new paths for ongoing motivation and involvement in sustainable commercial transportation. Beyond devices like OptiDrive, these technological developments include smartphone apps like

Fuelio [31] and *Fleetio* [32], which have been crucial in tracking vehicle maintenance and fuel use. These apps assist in maximising driving patterns for fuel economy by providing real-time data to drivers. Furthermore, gamification, as shown in applications like *GreenRoad Drive* [33], integrates game aspects into daily driving chores, thereby improving the motivation for environmentally responsible driving via rewards and leaderboards. By offering complete analytics on vehicle performance, driver behaviour, and environmental impact, telematic data collecting systems like *Trackunit* [34] also play a major part. Such solutions enable fleet managers to make well-informed decisions resulting in lower carbon emissions and improved operational effectiveness. Therefore, the trucking sector is making major progress towards a more sustainable and safe future by integrating these technologically driven solutions with conventional training courses.

Building on the integration of technology innovations and conventional training approaches in improving sustainable commercial transport, it becomes clear that knowledge of the underlying psychological and motivating theories is vital. This investigation of drivers' motivations, especially using theories like Self-Determination Theory, allows a basic framework for understanding the success of these approaches in encouraging long-lasting environmentally friendly driving behaviour.

5.1 Motivational Theory

The *Self-Determination Theory* (*SDT*) [35] is one of the well-known motivating theories that aids to grasp drivers' effort for environmentally friendly behaviour. According to *SDT*, people drive for various reasons, including both extrinsic and intrinsic ones, which can also be applied to environmentally responsible driving habits. Furthermore, studies on motivation, best shown by Locke and Latham's *A Theory of Goal Setting & Task Performance* [36], have underlined the need of clearly defining goals and objectives to propel performance. It underlines how motivated people are to reach intended results mostly depending on properly defined goals.

Research by Ambrose and Kulik from the 1990s, as reported in *Old Friends, New Faces: Motivation Research in the 1990s* [37], looked at the particular elements that drive workers in the workplace, including rewards, recognition, and the nature of the work itself. Likewise, Deci's 2017 paper *Self-determination theory in work organisations* [38] built on this by stressing the need of **autonomy**, **competency**, and **relatedness** in raising employee motivation. These studies together offer a whole picture of motivation in the workplace, showing how different elements greatly affect staff performance and behaviour.

Furthermore, with its emphasis on educational environments, the *Handbook of Motivation at School*, edited by Wentzel and Miele [39] provides insightful analysis. The guidebook shows that motivation is a complicated and varied notion including elements of intrinsic and extrinsic motivators, student involvement, and the effect of social and emotional aspects on learning. Applying these ideas to the trucking sector helps one to deduce that a comparable spectrum of incentives affects driver behaviour. For example, one can efficiently use extrinsic elements like awards and recognition as well as intrinsic motivators like personal satisfaction and a sense of achievement to inspire environmentally friendly and safe driving behaviour.

The Self-Determination Continuum, shown in Figure 1, provides a comprehensive picture of multiple types of motivation. Points on this continuum span from *Amotivation* (lack of motivation) to *Intrinsic Motivation* (motivation fueled by internal satisfaction). Between these extremes are several types of extrinsic motivation such as *External Regulation*, in which behaviour is motivated by outside incentives or penalties and *Integrated Regulation*, in which actions closely coincide with personal values and beliefs.

For example, motivating truck drivers depends critically on *Identified Regulation*, a stage in which people recognise and embrace the personal relevance of a behaviour. When drivers understand and value the benefits of eco-friendly driving practices, such as reduced environmental impact and fuel savings, they are more likely to adopt these behaviors consistently. This continuum not only offers a graphic depiction of the intricate terrain of motivation but also helps the development of strategies meant to inspire drivers towards more environmentally friendly behaviour. Knowing where drivers currently sit on this continuum helps interventions be customised to guide people towards more self-determined kinds of motivation, therefore improving their long-lasting commitment to environmentally friendly driving.

5.1.1 Complementary Motivational Theories

In the search of understanding and boosting intrinsic motivation for environmentally friendly driving behaviours, it is useful to also consider complementary motivational theories in order to further enrich the understanding and provide a comprehensive framework.

Goal Setting Theory (GST) [36] is behind emphasising the need of establishing clear, demanding, and reasonable objectives to improve intrinsic motivation and performance. Using *GST* in the framework of environmentally beneficial driving means giving truck drivers particular goals, such a 10% fuel consumption cut within six months. These goals provide direction and purpose, motivating drivers to adopt sustainable practices. Regular progress tracking, driver feedback, and incentives for goal attainment help to further support the integration of *GST* in eco-driving programmes. Setting challenging goals, combined with systematic feedback and rewards, aligns with Goal Setting Theory principles and effectively

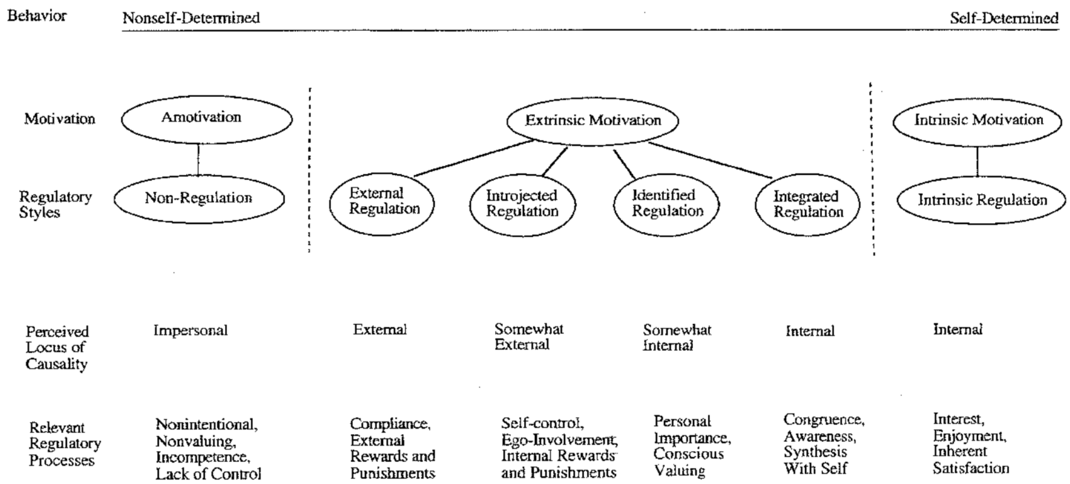


Figure 1: Self-Determination Continuum Showing Types of Motivation With Their Regulatory Styles, Loci of Causality, and Corresponding Processes.

may promote long-term environmentally friendly driving practices.

At last, *Achievement Goal Theory (AGT)* acknowledges the variety in personal objectives, which span performance to mastery or even work-avoidance [40]. Applied to environmentally responsible trucker driving, this theory proposes different drivers' motivations. While some drivers might be driven by performance goals, such exceeding their peers in fuel economy measures, others might concentrate on safety and avoid jeopardising their road safety at all costs. Understanding and accommodating these varying motivating factors enables one to create more intrinsically driven ecological initiatives. For those aiming for safety, for instance, offering the safest routes; for those driven by performance, create friendly contests. These kinds of customised methods assure that eco-driving programs are more interesting and successful for all kinds of drivers since they corresponds with *AGT* ideas.

Combining all these theories helps to create a thorough and linked framework for inspiring truck drivers to intrinsically adopt sustainable driving habits over the long run.

6 Literature Review

Overcoming the motivating obstacles in the trucking sector calls for the integration of gamification according to growing research and industry insights in recent years [5]. Though its influence on motivating long-term has not been as successful [7], gamification has been successfully applied in various fields to improve user engagement and drive short-term behaviour change. Including game-like components such as points, badges, leader-boards, and rewards into the framework of truck drivers' employment helps one to leverage their initial motivation [41], making eco-friendly and safe driving practices more engaging and personally rewarding.

Several earlier studies have looked at how gamification might be used to encourage environmentally friendly driving practices. In their meta-analysis, Hamari et al. looked over 24 empirical gamification investigations. Although gamification generates favourable results in various situations, they discovered that these benefits are quite reliant on context and the people engaged [42].

In their study, Huotari and Hamari offer a framework, differentiating gamification from playful design [43]. They contend that the fulfilment of psychological demands and the seeming significance of the action generate meaningful participation in gamified systems. Johnson et al., concentrating on the health industry, examine 19 gamification studies. Their results imply that gamified interventions can be successful but differ substantially depending on design elements, user traits, and context [44]. The insights from this study inform the development of gamified systems for truck drivers, emphasizing the need for customization to individual drivers and contexts.

In another study, Froehlich et al. created a sensor-based mobile app to offer feedback on transportation behaviour [45]. Over three weeks, the study comprised of a real-world trial involving thirteen volunteers. A significant increase in walking and biking among participants clearly indicated that *UbiGreen* successfully motivated consumers to embrace more environmentally friendly transportation choices.

Another Froehlich's et al. study, *The Design of Eco-Feedback Technology*, involves designing and evaluating interactive eco-feedback systems. They highlight the importance of personalisation, actionable feedback, and the presentation of historical data in promoting sustainable behaviors. Their research concluded that well-designed eco-feedback technology leads to significant changes in users' environmental behaviors [46].

These studies collectively underscore the intricacy and possibilities of gamification and eco-feedback systems. They reveal that although these techniques are useful, their success depends on careful design and understanding of user-specific issues. Particularly, the studies of Froehlich et al. show how practically these ideas can be used to promote environmentally friendly transportation choices.

Going forward, the present study explores five creative initiatives, greatly supported by the European Union and presented on the CORDIS website [47]. Though different in scope, these projects together provide a rich source for investigating aspects of environmentally responsible behaviour. They include not just analysis of several strategies for sustainability but also a clear foundation for developing a distinctive and strong thesis project. Whether these initiatives directly incorporate gamification or other environmentally friendly approaches, their investigation helps one to grasp the larger background and possibilities of influencing eco-friendly transformation across various domains.

6.1 GamECAR

For instance, the *GamECAR* platform employs a robust data retrieval and processing infrastructure to capture nuanced vehicle and driver status parameters, which are then translated into a tailored gamified experience. At the heart of this data-driven initiative are a series of scoring algorithms that analyze driving behaviors. For instance, the eco-score penalizes high engine RPM values (stand for "Revolutions Per Minute," and indicate the speed at which the engine's crankshaft is spinning) during gear shift-up, abrupt braking, and high acceleration. Meanwhile, the aggressiveness score takes into account high lateral acceleration and variances in throttle position and RPM. These scores are computed within a 30-second temporal window using mathematical functions like sigmoid and weighted histogram functions, to categorize different driving events and compute penalties or rewards accordingly.

The project also employs the Q Methodology process for research design, drawing from qualitative research conducted in the ecoDriver project [48]. This involved 71 individuals from various national backgrounds exploring 32 statements concerning the features of an eco-driving system, categorized under Installation, Feedback/Information, Gamification, and Input Variables.

As seen in Figure 2, on the gamification front, the platform's methodology is a rich tapestry of storytelling, goal-setting, challenges, and a progression system through game stages, each catering to different player types identified as "Constant Improver," "Safety Enthusiast," and "Smart Saver". Players' main interaction with GamECAR is through driving, with an eco-score calculated after each trip. Specific driving skills and behaviors, such as fuel consumption and braking, are assessed and linked to desired game behaviors.

The primary tool for customizing the game experience is mission objectives, tailored to each player type. *Constant Improvers* are challenged to surpass their previous performance, *Safety Enthusiasts* concentrate on consistent and eco-friendly driving, and *Smart Savers* are encouraged to reduce fuel consumption and promote environmental impact. The effectiveness of gamification features relies on the core drives that should be leveraged, depending on each player's category and the phase of the game. For instance, early phases emphasize "Epic Meaning," while later stages prioritize "Loss and Avoidance," "Accomplishment," and "Social Influence."

The *GamECAR* journey unfolds in four distinct phases:

- *Discovery* (Levels 1 to 4) where users become acquainted with game elements and basic driving statistics.
- *On-boarding* (Levels 5 to 14) introducing advanced features like leaderboards, daily missions, and loot boxes.
- *Scaffolding* (Levels 15 to 39) focusing on habit formation and crew creation.
- *Endgame* (Levels 40 to 50) where players receive personalized feedback, access advanced performance visualizations, and experience inactivity decay for customized features based on their detected player type.

All these gamification elements are intertwined with real-time feedback mechanisms, ensuring that drivers are not only cognizant of their driving habits but are also motivated to improve. Moreover, the gamification extends to avatar customization, allowing a sense of ownership and social competition among peers.

The *GamECAR* system was evaluated in test campaigns with drivers in the UK, Spain, and France. Overall, the study found that users did not rank sharing information or competing with others highly. Also, avatars or character customization did not appeal to them. Although there was agreement on avoiding distractions, clear preferences emerged for safety, economic savings, and feedback/improvement. The Q methodology effectively identified user needs and expectations, which can guide the development of a better user experience that helps to develop long-lasting eco-driving habits.

6.2 GAFU

Similarly, the *GAFU* (Gamification to Save Fuel) tool was desgined to assess the impact of gamification tools on eco-driving habits using an eco-driving assistant deployed on various Android mobile devices. The assistant

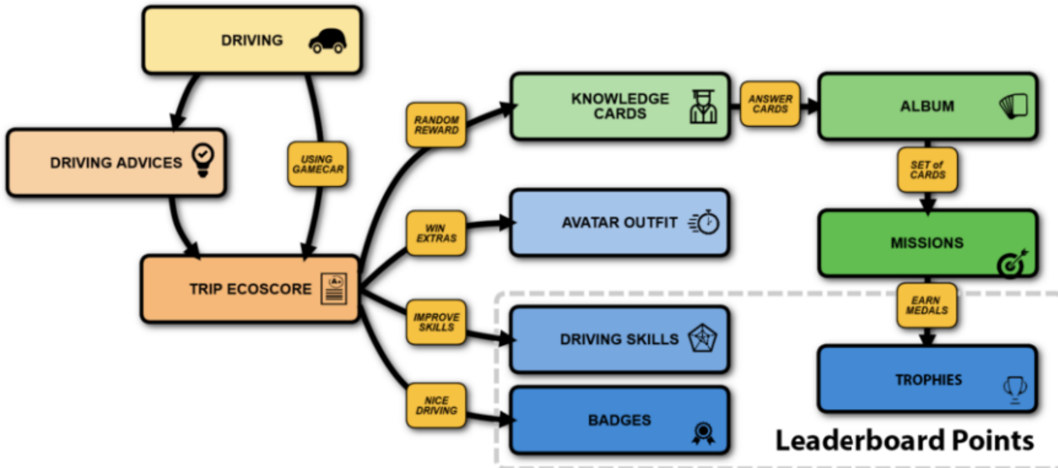


Figure 2: GamECAR gamification design.

utilized vehicle data from the *OBDLink OBD Interface Unit*, which provided parameters like vehicle speed, fuel consumption, engine speed, and acceleration.

The experiment involved 2160 test drives with 36 different drivers, spanning three routes in Granada (A), Seville (B), and Madrid (C). Each route offered a blend of highway, urban, and secondary road segments. The trials were conducted under uniform conditions during specific months in 2013. Notably, preliminary tests comprising 60 rounds were undertaken in 2012 without the provision of eco-driving tips, representing the performance of the Initial Group. For the main study in 2013, drivers were categorized into two distinct groups. The Control (or Test) Group was given traditional eco-driving tips, while the Experimental Group benefited from the integration of gamification elements, providing them with real-time feedback on scores, achievements, and peer comparisons. Three diverse vehicle models were employed across the routes to ensure varied driving experiences.

The *GAFU* architecture integrated real-time updates on weather and traffic conditions and provided auditory feedback and eco-driving tips tailored to each driver's behavior and situation. Telemetry data, including GPS information, speed, fuel consumption, and engine performance, were transmitted to a central system for processing. Drivers were categorized into clusters based on various criteria such as driving style, time of travel, geometrical location etc., facilitating more personalized feedback.

Drawing from the insights outlined in Figure 4, the Experimental Group exhibited improved driving habits, with lower acceleration and deceleration rates, consistent kinetic energy levels, and reduced occurrences of high engine speeds and elevated velocities. This group achieved an average reduction in fuel consumption of 8.91% to 9.66% across different routes compared to the Control Group. While the gamified approach in the *GAFU* system has demonstrated a positive impact on eco-driving behavior in the short term as evidenced, further research is needed to assess its long-term effectiveness and potential for broader application.

6.3 EcoDriver

In the evolving domain of eco-driving systems, the EcoDriver project [49], developed various eco-driving support systems and tested across different vehicle types and powertrains (system that propels a vehicle by converting energy from fuel or electricity into motion), ranging from low-cost solutions like an Android app to more complex ones like the Full ecoDriver System (FeDS), which demonstrated the project's Human-Machine Interface designs and energy calculation software. Embarking on a comprehensive exploration of eco-driving systems, as detailed in the paper by Jonkers and colleagues [48], the project underwent a robust evaluation framework.

EcoDriver's evaluation methodology followed a four-step framework: scenario development, traffic simulations, scaling up, and cost-benefit analysis (CBA), all underpinned by comprehensive data collection from three primary sources: 1) driver behavior from controlled studies, 2) Human-Machine Interfaces (HMIs) logging driver interactions and recommendations, and 3) vehicle performance metrics tracked via the CAN bus for detailed powertrain monitoring. This diverse data was centralized on a server for thorough analysis. Nine eco-driving support systems were rigorously tested under real-world conditions, facing challenges due to differences in systems, vehicles, data collection setups, and experimental plans. Two testing methodologies were used: "controlled" drives on set routes with an observer recording behaviors, and "naturalistic" drives reflecting everyday use across various test sites. Experimental designs differed between sites, adding complexity, but an adapted analysis model effectively managed these variations for

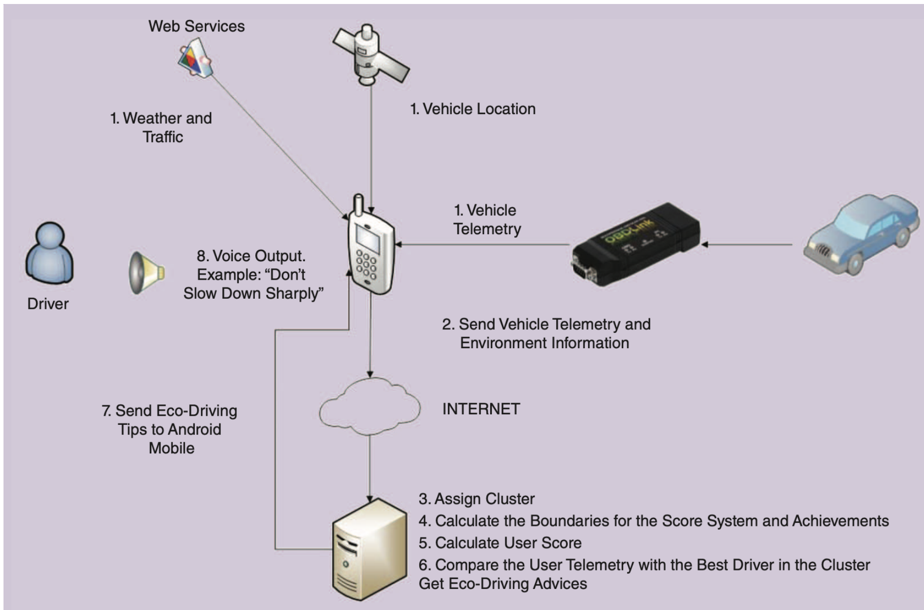


Figure 3: GAFU awareness game architecture.

meaningful statistical evaluation.

This endeavour led to the inception of three distinct scenarios; *Green Future*, *Policy Freeze*, and *Challenging Future*, each illuminating various facets of green driving support, technological advancements, and policy frameworks. The *Green Future* scenario appears the most optimistic in terms of technology development and supportive attitudes, yet it is characterized by high fuel prices. The *Policy Freeze* scenario represents a middle-ground situation, while the *Challenging Future* scenario is notably the most pessimistic.

Transitioning from theoretical frameworks to practical applications, the project embarked on an extensive phase of real-world field trials. This phase saw 170 drivers across seven European countries delving into the practical realm of EcoDriver systems, testing the approach with tailored speed and gear advice. This real-world testing bore fruit with an average reduction of 4.2% in fuel consumption and CO_2 emissions, showcasing a pronounced impact on rural roads with savings peaking at 5.8%. As the project transitioned into the traffic simulation phase, microscopic modeling on small networks offered a lens into how EcoDriver systems influence emissions, fuel consumption, and safety metrics across diverse road environments and traffic demands. This simulation exercise served as a conduit, linking real-world trial findings with broader traffic dynamics and enabling a glimpse into potential large-scale impacts.

Incorporating the Cost-Benefit Analysis (CBA) into the evaluation revealed a reasonable confidence in the worthiness of the system for drivers, based not only on fuel savings but also on other sizable benefits despite some time losses experienced by the driver. Some of the benefits also extended to others on the road, like the enhanced safety which was significant. The ecoDriver system showed a notably positive case for buses and trucks, and for a representative European diesel car with typical mileage, the fuel savings could easily justify the system's purchase. The scenarios of "Policy Freeze" and "Green Future" exhibited good Benefit-to-Cost Ratios (BCRs) indicating that the benefits outweigh the costs, whereas the "Challenging Future" scenario displayed a BCR below 1, signifying higher costs than benefits. Real-world trials hinted at the possibility of doubling the ecoDriver system's effectiveness with further optimization, as compared to traffic simulations. Furthermore, a sensitivity analysis, assuming an optimized ecoDriver system implementation, showed a strong positive impact on the Net Present Value (NPV), albeit the Benefit-Cost Ratio to government was just 'good' due to increased indirect tax revenue losses from fuel taxes.

As seen from Figure 5, the study assessed the efficacy of the EcoDriver systems across the EU-28. It found that these systems led to a modest decrease in CO_2 emissions and fuel usage, with reductions ranging between 0% and -1.7%, depending on specific future scenarios. Real-world trials showed energy savings between 2% to 6% and exhibited positive impacts on driving behaviors like speed and acceleration, which can potentially lead to less severe crashes. Their most significant impact, however, was the improvement in road safety due to vehicles operating at reduced speeds, especially on rural roads which make up over half of EU-28's total road mileage. From an economic standpoint, the *Full EcoDriver system*, which is 3% more effective than the mobile app version, provided a positive social Net Present Value, particularly in environmentally favorable scenarios. This embedded system is especially promising for high-mileage vehicles such as

	Route	Initial Test	Control Group	Experimental Group
Average acceleration (m/s^2)	A	0.88	0.54	0.47
	B	0.70	0.6	0.58
	C	0.61	0.72	0.61
Average deceleration (m/s^2)	A	0.85	0.56	0.52
	B	0.69	0.6	0.55
	C	0.75	0.6	0.54
Positive kinetic energy (m/s^2)	A	0.55	0.33	0.26
	B	0.53	0.36	0.28
	C	0.40	0.28	0.26
High engine speed	A	12.57%	11.14%	3%
	B	0%	0.18%	0%
	C	7.71%	6.50%	1.37%
High speed	A	4.64%	0%	0%
	B	8.50%	2.07%	0%
	C	6.93%	2.44%	0%
Standard deviation of vehicle speed	A	3	1.74	1.45
	B	2.29	2.08	1.83
	C	2.09	1.95	1.64
Score (0–10)	A	1.5	3.56	7.00
	B	2.25	2.9	6.02
	C	2.59	4.66	7.02

Figure 4: Results obtained during 60 tests for each group.

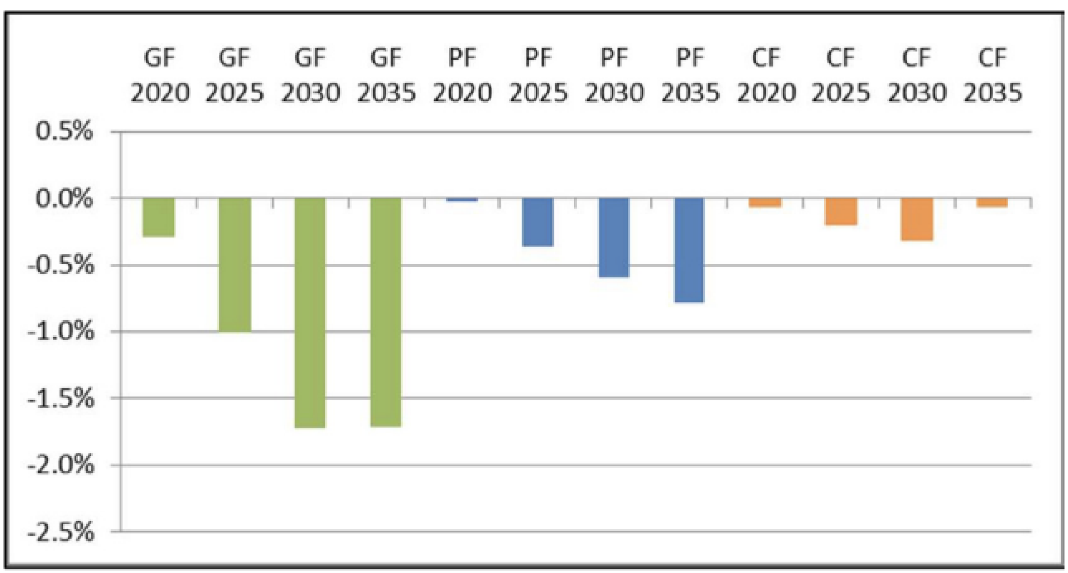


Figure 5: Impact of EcoDriver systems on CO_2 emissions for EU-28.

buses, trucks, and fleet cars.

In conclusion, the EcoDriver project symbolizes a meaningful stride towards unraveling and promoting the potential of eco-driving systems in Europe. It underlines the imperative for advancing methodologies in scaling up and data collection, contributing a robust scaffold to the academic discourse and policy formulation concerning eco-driving and Intelligent Transportation Systems (ITS). Moreover, the systems encouraged a driving style aligning with eco-driving principles and the quality of the system significantly affected the change in driving behavior. Differences in results between controlled and naturalistic experiments highlighted the need for further investigation, especially in understanding long-term impacts.

6.4 Eco Drive

Following the comprehensive exploration of eco-driving systems by the EcoDriver project, a subsequent initiative known as the Eco Drive project [50] took the initiative to delve into eco-efficient powertrains specifically. Despite its focus on eco-powertrains rather than fleet vehicles, the Eco Drive project remains important as it addresses the broader agenda of reducing vehicular emissions and enhancing eco-efficiency. It aims to develop innovative technologies for testing and simulating these powertrains while tackling challenges related to noise and vibration. It emphasizes tough technical challenges, international collaboration, and interdisciplinary approaches.

Eco Drive employs a unique structure: a radar chart. Each distinct segment, representing various vehicle performance dimensions like "Acoustics", "Vibration", and others, originates from a central point and extends outward. These extensions are divided into levels, much like the concentric circles on a spider web. Although there are technically 6 levels from the outermost circle to the center, the actual measurable differences between them amount to 5, as the central point acts as the starting reference. This distinction in levels allows for a somewhat clear gradation of performance, with each jump from the center indicating a step-up in that particular dimension's achievement or focus. By understanding these levels, one can gauge the degree of importance or achievement allocated to each category over time.

In its pursuit of eco-efficiency in powertrains, the Eco Drive project focused not only on technological advancements but also on active public and academic engagement. A prominent document reflecting this is the D5.8 Intermediate Public Engagement Report [51], coordinated by Milena Martarelli (UNIVPM) and Paolo Chiariotti (POLIMI), covering the engagement activities from March 1st, 2020 to February 29, 2024. Despite the challenges posed by the COVID-19 pandemic, the project maintained a vibrant interaction with the public and the academic community, with the involvement of thirteen Early Stage Researchers. Key activities included conference sessions in June 2021 and a further one in September 2022. Moreover, noteworthy public events like the Kinderuniversiteit event on 3 October 2020 and the Ignaz Kögler Acoustic Research Camp presentation between 27 September and 1 October 2021, showcased the project's commitment to outreach. These engagements, as the report indicates, not only disseminated the project's findings but also fostered a broader understanding of its objectives in reducing vehicle emissions and advancing eco-efficient powertrains, thus aligning with the broader EU's green transport ambitions.

6.5 EnCompass

Building on such momentum, the enCompass project [52] took a broader approach, aiming to cultivate energy-saving behaviors and habits among European citizens.

At its core, enCompass utilizes a socio-technical methodology, intertwining research on energy consumption dynamics with tangible digital solutions designed to inform, inspire, and incentivise energy-efficient behavior. Figure 6 illustrates an integrated approach to energy management and user engagement. Initiating with data acquisition through smart meters and sensors, the information is channeled to a central repository for consumption. From here, the data diverges to two primary domains: consumer applications and data analytics. The former focuses on delivering visualization, awareness, and feedback to users, further enriched with gamified incentives, goals, and adaptive recommendations to drive behavior change. Simultaneously, the analytics segment delves into data disaggregation, activity detection, and the development of end-user models; categorizing building features, clustering users, and forecasting demand. Serving as the nexus of the system, the intelligent control interacts bidirectionally with both user engagement tools and building models, striving to optimize decisions for reduced energy consumption. Central to the system's integrity is an unwavering commitment to privacy and security, ensuring the safeguarding of user data and operational procedures.

Moreover, building upon the SmartH2O project's [53] invaluable insights, enCompass pioneered the creation of the MyEnCompass app, a tool replete with intelligent data visualizations, actionable energy-saving recommendations, and gamified structures to drive robust user engagement, as seen in Figure 7. The app further boosts the initiative's reach by promoting energy-saving competitions, albeit exclusive to invitees, nurturing a spirit of community-driven sustainability.

Another aspect to note is that a key part of the project's engagement strategy was the Funergy game (Figure 8), a hybrid digital-physical initiative available on both Android and iOS. Designed as an interactive board game that melds with a digital app, Funergy immerses players in challenges that combine cooperative and competitive strategies to acquire energy-saving

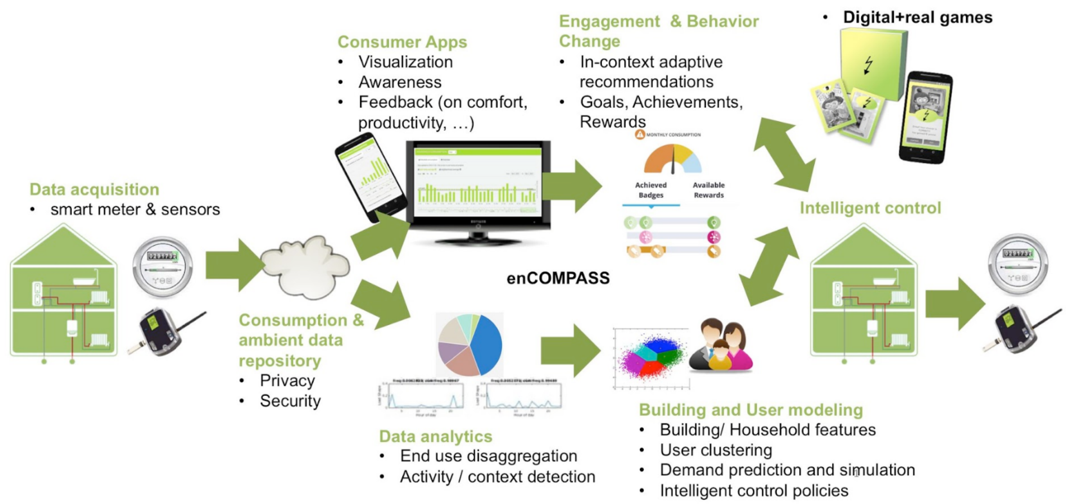


Figure 6: enCompass Methodology Diagram.

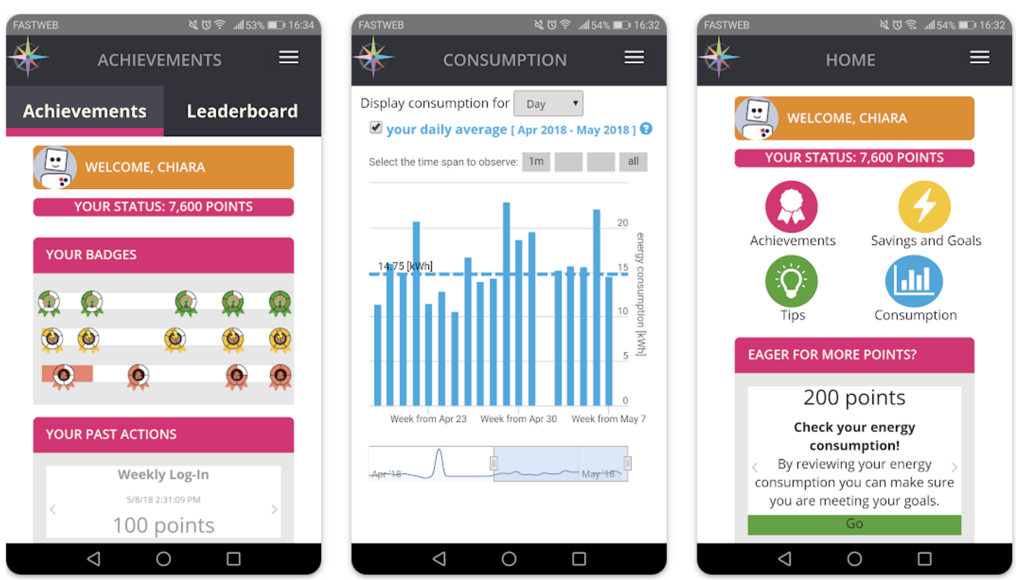


Figure 7: MyEnCompass app interface.

points. This strategy underwent extensive validation in Italy and Switzerland, involving over 1,500 students as participants. Through energy-related quizzes, the game educates and deepens the knowledge of players, especially children and families, about crucial environmental and energy issues, making learning fun and intuitive.

Beyond individual behavior change, enCompass aimed to influence energy management companies and energy demand management policies on a broader scale, contributing to a more secure, clean, and efficient energy future. Ensuring its relevance, the system underwent rigorous validation across diverse European nations, including Germany, Greece, and Switzerland, each situated in different climate zones and building types (schools, residential buildings, public office buildings). These pilots, based on a holistic approach for behavioral change, utilized an original mix of gamified incentives, adaptive energy-saving recommendations, and smart devices, grounded in a theoretically sound behavioral change methodology expected to have a lasting impact on energy consumption.

To assess the energy savings and behavior changes, a before-after comparison was performed, alongside a treatment (enCompass users) vs. control group comparison. This comparison indicated reduced energy consumption compared to a control group, positive change in energy knowledge in the treatment group using the system, and positive user feedback about the system's suitability.

To build upon these initial findings and address the crucial question of the long-term effectiveness of such interventions, a follow-up study was conducted, specifically focusing on the extended impact of the enCompass app as part of a policy intervention in Contone, Switzerland from June 2018 to May 2019. The study used a quasi-experimental approach on 55 self-selected households, comparing them with a control group over four years of electricity data.

The results showed that during the intervention, the enCompass app led to a 4.95% average reduction in household electricity consumption and emissions, with a small effect size. For households using electricity solely for non-heating purposes, the reduction was 14.46% with a large effect size. However, these effects were not maintained in the long term, with consumption returning to pre-intervention levels in follow-up periods.

These findings challenge the effectiveness of using such apps for long-term energy-saving policy, suggesting that other interventions might be more sustainable. The lack of sustained effects also raises questions about the impact of community feelings on short-term energy-saving practices. Therefore, it can be concluded that future research should focus on larger, randomized samples and explore the role of community engagement in energy-saving efforts, potentially within living lab frameworks or renewable energy communities.

6.6 Wallius and Köse Review

Building on these broader implications, the evolving landscape of research in this field is further illuminated by the 2023 systematic literature review by Wallius and Köse [5], presented in the Proceedings of the 7th International GamiFIN Conference. This review comprehensively synthesizes findings from 17 distinct studies on gamified eco-driving, highlighting the significant role of Information Systems (IS) in enhancing energy efficiency in passenger road vehicles amidst escalating societal and environmental challenges.

Central to their review is the investigation of various gamification strategies, such as performance-based and social gamification. These strategies aim to cultivate a wide range of eco-driving behaviors by addressing the motivational barriers faced by drivers. Motivation thus becomes the crucial linchpin, acting as a bridge between awareness and tangible action, thereby facilitating the transition to eco-friendly driving practices.

As illustrated in Figure 9, gamified eco-driving boasts a range of techniques and strategies. The "Performance" category stands out, with ten studies employing points or scores, emphasizing their foundational role in eco-driving gamification. Feedback, spotlighted in nine studies, not only engages but also guides users. The importance of badges and levels is evident, each being featured in four studies. In the "Personal" category, challenges or objectives play a notable role, highlighted in four studies, suggesting the significance of personal milestones.

Beyond introducing innovative tools, this review profoundly addresses the influences on driver psychology. The practicality of these techniques is validated by three studies emphasizing their perceived usefulness. Moreover, two studies focused on emotional aspects like fun and joy, suggesting that user enjoyment is crucial in fostering eco-conscious driving habits. From a behavioral standpoint, four studies assessed the techniques' influence on driving speed, while three delved into their effects on energy or fuel consumption.

The "Social" gamification aspect sees leader-boards or rankings at the forefront, evidenced in eight studies. The "Ecological" and "Fictional" gamification categories, albeit less explored, also offer intriguing aspects. While individual studies have shown that elements like avatar-themed collectibles and storytelling techniques can engage users, their presence does not necessarily indicate a high level of importance in the broader context of user engagement.

Wallius and Köse's deep dive into gamified eco-driving offers invaluable insights into the myriad ways gamification strategies can shape driver psychology and behavior. Amidst the pressing environmental challenges of today, such techniques stand out as potent tools in championing sustainable and eco-conscious driving.

Figure 8: enCompass Funergy game.

7 Grounding the problem

While earlier studies offer a strong basis for using gamification to promote environmentally friendly driving practices, additional research is needed to evaluate its long-term effectiveness and the underlying psychological mechanisms engaged in this regard.

The rising need of this research is highlighted by the pressing issues of reducing carbon emissions, saving energy, and advancing road safety; all important problems at the forefront of contemporary transport, demanding creative ideas. Carbon emissions and energy consumption are mostly caused by the commercial transportation sector [6]. Table 1 statistics shows the scope of the challenge. For example, the table shows the transport sector alone accounts for a substantial 24% of global CO_2 emissions, while trucks are projected to contribute significantly to future emissions and oil demand growth. These numbers highlight the need of tackling eco-driving habits in the search of more environmentally friendly transportation solutions.

By means of an empirical analysis, the present work researches how the addition of efficient game-style techniques, together with intrinsic motivation principles, can affect truck drivers' behaviour to establish enduring eco-friendly and safe driving habits in the framework of Bridgestone Mobility Solutions' Webfleet application. Given the advantages and constraints of gamification as a motivating tool, the project creates an optimal plan that promotes sustainable driving behaviour not only in the near future but also helps to establish these behaviours into long-standing habits. Understanding the limited time available for this research, the initial emphasis of this project is on the fleet managers' immediate perceptions of the developed gamified training approach.

Research Questions:

To aid a holistic approach, a set of research questions has been identified, which were addressed. Subsequently, the corresponding hypotheses for these questions were presented.

1. What are the advantages and limitations of incorporating gamification elements into eco-driving initiatives, and how do they impact drivers' initial engagement?
2. What strategies and interventions contribute to sustained eco-friendly driving behaviours over an extended period, and how can they be integrated into gamification approaches?
3. How do drivers' perceptions of gamification change over time, especially in relation to their intrinsic motivation and understanding of eco-friendly driving?

Hypotheses:

Hypothesis (H_1): Incorporating gamification elements into eco-driving initiatives offers advantages by initially increasing drivers' engagement and motivation,

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)	-

Figure 9: Synthesis of the results.

Table 1: Key Freight and Eco-Driving Statistics

Statistic	Value
CO_2 emissions from transport sector	24% [54]
CO_2 emissions from freight sector	7% [55]
Share of oil demand growth by trucks by 2050	40% [56]
Increase in CO_2 emissions due to trucks by 2050	15% [56]
Decrease in truck emissions in 2020	5% [57]
Time for freight emissions to rebound	1 year [57]
Fuel saving potentials from eco-driving	6.8% to 27% [58]

but it also presents limitations related to the potential for short-lived effects on long-term behavior change.

Hypothesis (H_2): Implementing strategies and interventions that emphasize intrinsic motivation through personalised profiles, missions, feedback and community engagement within the WorkUp application is expected to contribute to sustained eco-friendly driving behaviors over an extended period. When integrated as gamification approaches, they have the potential to enhance their long-term effectiveness in fostering eco-friendly driving habits.

Hypothesis (H_3): Drivers' perceptions of gamification evolve over time, with initial engagement driven primarily by gamification elements. However, sustained behavior change is more closely related to intrinsic motivation and a deeper understanding of eco-friendly driving, highlighting the shift in drivers' perceptions as they progress in their eco-driving journey.

8 Methodology

The project's methodology places a primary focus on evaluating the driver's perception of the prototype within the given time constraints. A playable prototype was developed using *Figma*, providing a dynamic and interactive representation of the project's features. The approach is meant to fit several age groups, degrees of technical proficiency, and intrinsic motivations. Using motivating theories including *Self-Determination Theory (SDT)*, *Goal Setting Theory (GST)*, and *Achievement Goal Theory (AGT)*, the prototype ensures that missions are customised to inspire intrinsic motivation over multiple user profiles. Whether their objective is to drive safely, drive sustainably or save money, this method enables consumers to become involved in ecologically friendly driving in ways that are long-lasting. The project recognises the requirement of follow-up research to confirm its long-term efficacy while it seeks to encourage lifelong ecologically friendly driving practices.

8.1 Intrinsic Motivation

Driving long-term behavioural modification requires intrinsic motivation. As can be seen from Figures 11 and 10, users are assigned one of four distinct profiles depending on their intrinsic motivations during the on-boarding process upon first interaction with the application. These profiles are designed to speak the same language as the drivers by tailoring the game to their intrinsic interests, as reflected in the four distinct driver profiles, making the missions more relevant and motivating.

While users are allowed to change between profiles as desired, it is encouraged to remain with one profile per week to guarantee consistency and enhance the impact of the tailored missions. Within the missions, metrics show the advantages of sustainable practices and the effect of driving behaviour on the surroundings. These indicators enable consumers to better relate to the objectives of the missions by helping them to grasp the actual consequences of their activities. Features match consumers' own ideals, therefore boosting their intrinsic drive.

Focusing on cost reductions, **EconoMiser** shows consumers the yearly savings possible by completing environmentally friendly missions provided to them every trip.

Green Saver: Emphasising environmental impact of missions provided, this profile notes the gallons of petrol saved yearly.

Safety Enthusiast: This profile targets those motivated by safety and provides tasks stressing on safe driving techniques and their benefits.

Constant Improver: This profile is for individuals who are motivated by maximising their driving performance and provide missions that increase driving efficiency and lower vehicle wear and tear.

8.2 Missions, Community & Feedback

By offering particular goals and challenges that provide a sense of accomplishment, missions are fundamental in inspiring users similarly to the GameECAR project [59]. Designed to inspire their natural drive for environmentally conscious driving, the prototype comprises several individual tasks catered to distinct user profiles, as well as Weekly Team Missions.

As can be seen from Figure 12, drivers are provided missions as an active decision, allowing them to freely accept or reject based on their current situation. This approach ensures that choosing a mission is a con-

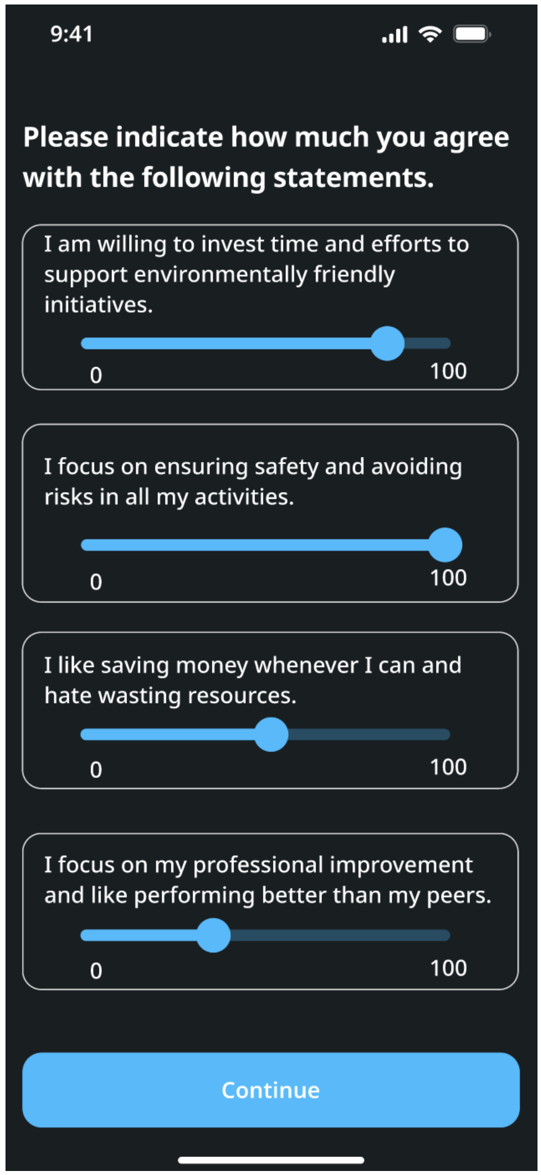
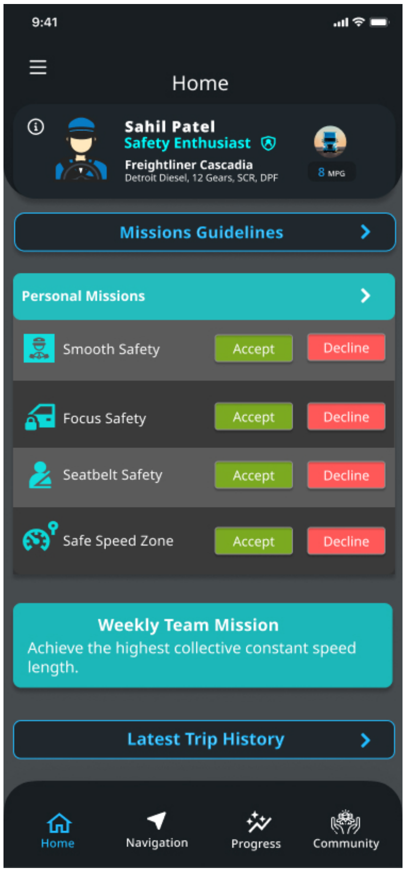
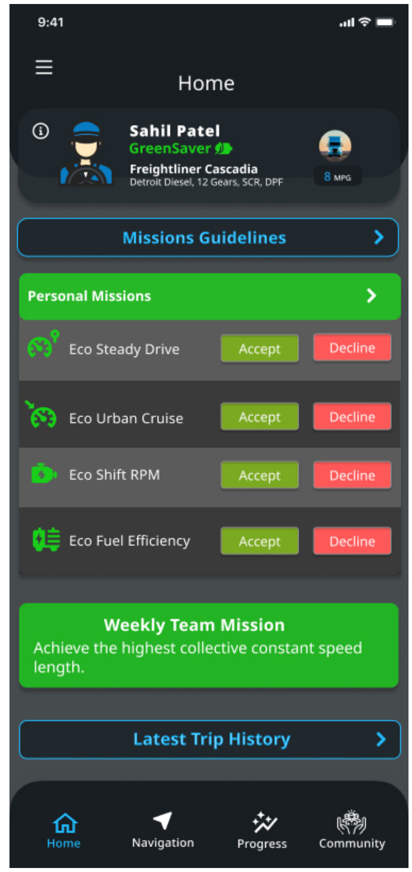


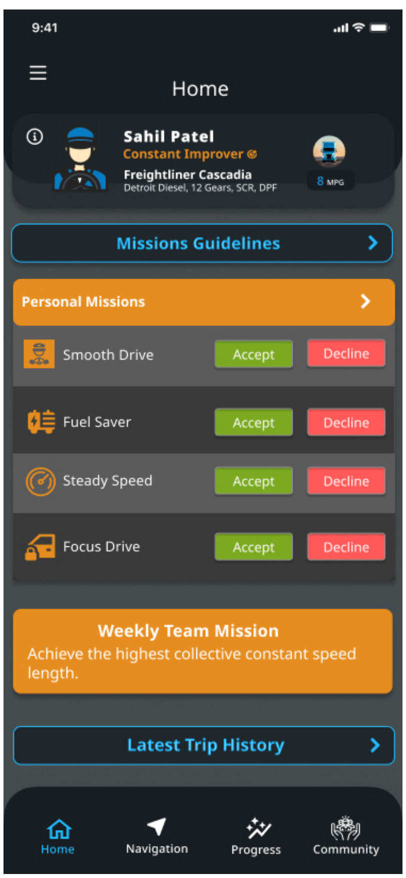
Figure 10: Initial onboarding.



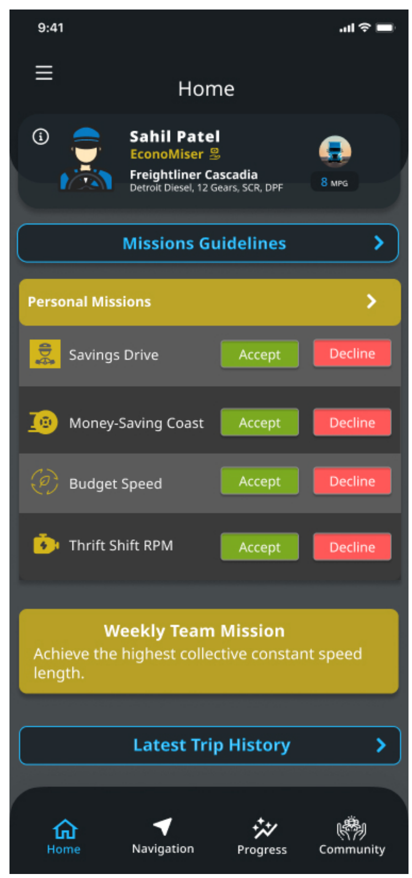
(a) Safety Enthusiast Profile.



(b) Smart Saver Profile.



(c) Constant Improver Profile.



(d) EconoMiser Profile.

Figure 11: Various Driver Profiles.

scious choice rather than a forced task, thereby enhancing their intrinsic involvement and dedication. If the driver chooses not to accept one or more missions, they will ultimately not be able to accumulate the maximum points. Consequently, this will hinder his ability to excel in both Solo and Team Ranking at the end of the week.

In the initial Personal Missions table , drivers see a brief description of each mission. To see the full details before deciding to accept or decline, they need to click on the Personal Missions arrow at the top of the missions box in each profile. This action expands the concise description into the full mission details, allowing drivers to make informed decisions. The detailed missions of all profiles can be found in Appendix B in Figure 28. Personal missions can call for reaching a given % decrease in fuel usage or driving a set distance using environmentally friendly methods. For example, as shown in Figure 13 for users in the SmartSaver profile, motivated by saving the planet, missions emphasize the annual fuel saving benefits of completing the task.

Figure 14 shows how users get live feedback while they drive about either succeeding or failing each accepted mission. To distinguish the missions in real time, users see the icon from the brief description of each mission on the Home Screen when they were accepting and declining the missions. Should a mission be successful, their effort earns 5 EcoPoints. Each trip they go on can result in up to 20 points overall for all four tasks. Should all four assignments be completed, they additionally get 10 bonus points for their committed effort. As seen in Figure 16, upon completing each trip, detailed progress towards earning a weekly medal is presented to them to prevent jeopardising their safety with distractions while driving. Additionally, the specific missions that were failed or achieved will be displayed to them in the Personal Missions table on the Home Screen after each trip is over, which can be seen in Figure 15.

Medals are earned if drivers accepted and completed all missions every trip in a week. They can also examine their past trips' driving progress by clicking on the All Trips tab in the Navigation page, can be seen in Figure 17, which shows the average company score for the driving behaviours of each of the previous trips. Alternatively, they can click on the Previous Trips tab shown in their profile page which shows their missions completion progress towards earning a medal (Figure 18).

Witnessing their progress not only keeps drivers inspired but also makes them feel successful. Figure 19 in the Overview tab on the Progress page offers periodic updates including feedback on particular driving actions such as coasting, idling, and speeding. These updates are available for today, the last 7 days, or the past month. Clicking the arrow next to each category will provide extensive comments allowing users to learn more about particular failures and successes, as well as the company score, for every driving activity. Furthermore provided to illustrate general performance is the average company score, which aggregates users' driving patterns considering all driving actions.

In the Achievements tab on the Progress page, weekly progress summaries allow users to monitor their missions completion and track their success in earning medals and badges, with their EcoScore points for each trip also recorded in this tab.

Weekly Team missions, which are the same throughout the week for all four profiles, can be found on the Community page of the app. They challenge teams to achieve communal goals such as maintaining the highest collective constant speed length. As seen in Figure 20, Team missions are evaluated at the end of each week in Team Rank tab of the Community page and help to promote a sense of shared purpose, boosting long-term sustainable behavior. Teams can receive 15 EcoScore points for 1st place, 10 points for 2nd place, and 5 points for 3rd place. This contributes to their ranking in the Weekly Solo Rank, which accumulates points from individual missions completed, medals, badges, and team ranks.

For scoring first in Solo Rank, the user gets 15 EcoScore points, with 10 and 5 points awarded for 2nd and 3rd places, respectively. Achieving 1st place in Solo Rank brings the user closer to earning a badge. Badges, which are the highest reward and hardest to achieve, can be earned by maintaining a top solo rank for two weeks and earning four consecutive weekly medals.

By fostering friendly competition through Solo and Team Ranks and rewarding consistent eco-friendly driving behaviors (that align with their intrinsic motivation) with points, medals, and badges, users are motivated to adopt and maintain sustainable driving habits. This continuous engagement and recognition mainly aims at instilling long-lasting eco-friendly driving behaviors.

Moreover, direct user communication made possible by in-app messaging, as seen in Figure 22, helps users to exchange ideas, encouragement, and support, hence strengthening a feeling of community and shared goal even further. Direct messages and group chats allow conversations on environmentally friendly driving techniques and the distribution of success stories.

8.3 Prototype Testing Methodology

The testing followed a three-part online process, taking about 45-60 minutes in total per person (N = 5). The steps were as follows:

1. Introduction and Presentation (10 minutes): The first step was to introduce and present the project's aims and objectives to the customers to avoid any further confusions and miscommunications in the process. In this initial step, the interviewees were also presented with the Interview Consent and Privacy Form, which can be found in Appendix A. After reading the Consent Form, it was signed online via DocuSign.

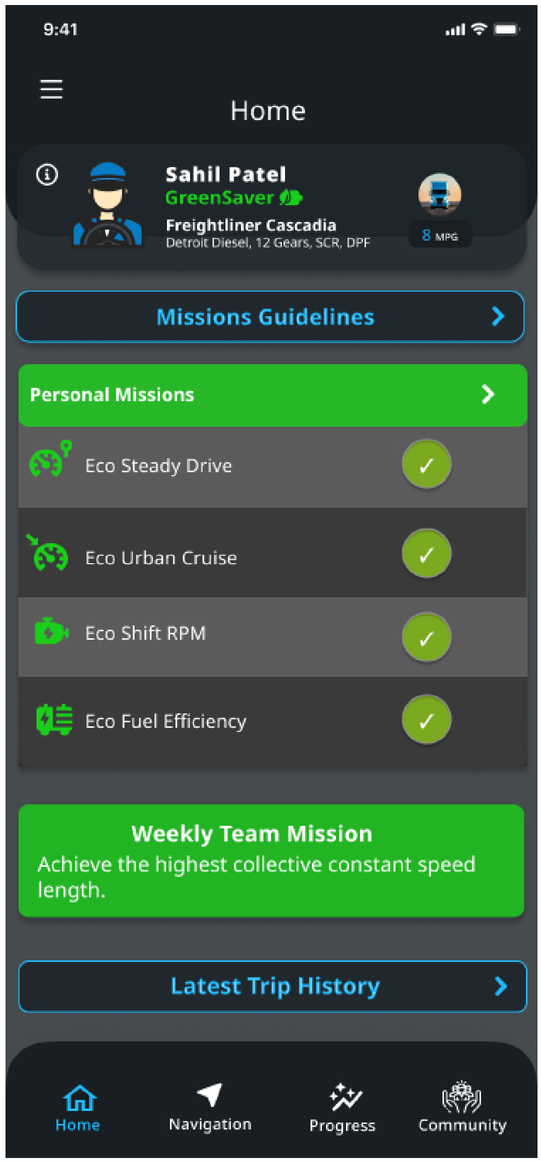


Figure 12: SmartSaver's Accepted Missions.

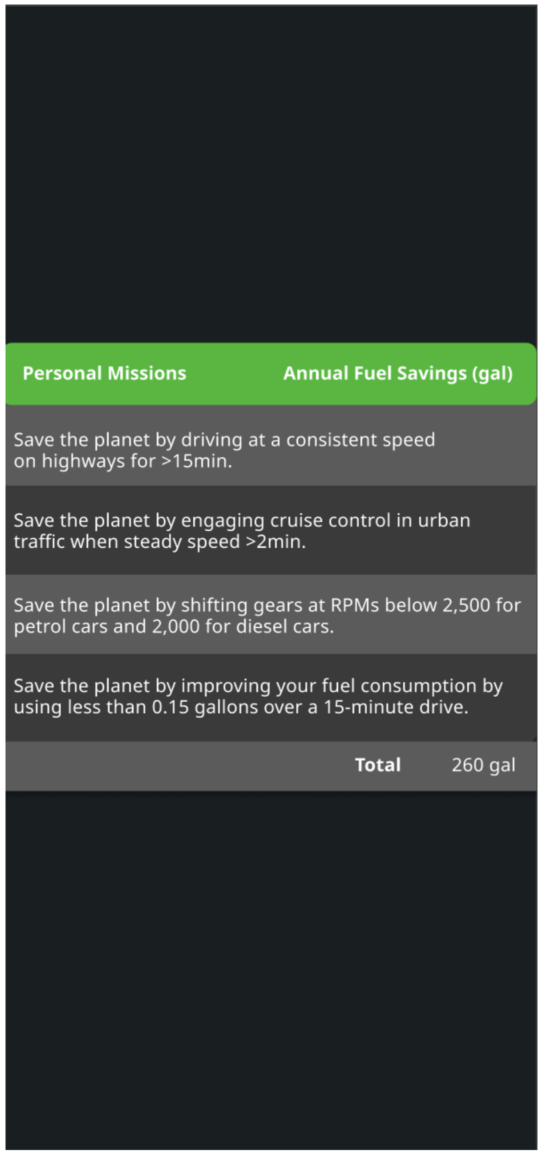
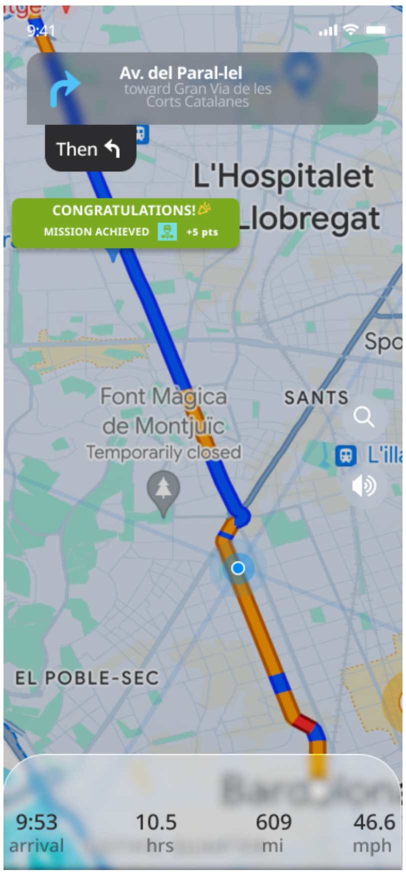
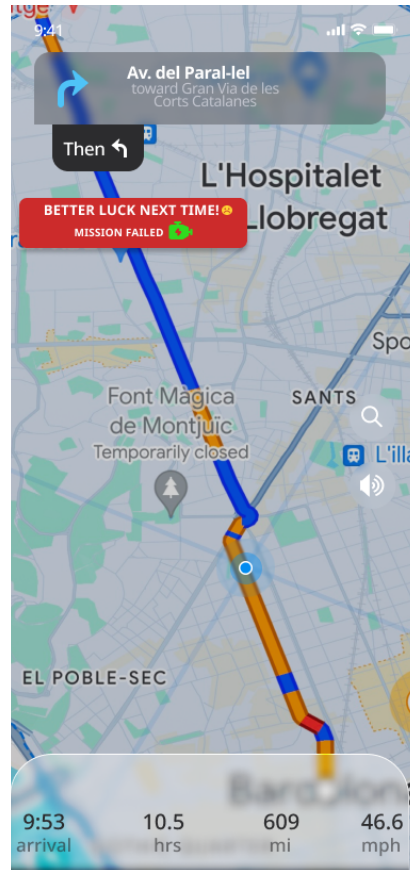


Figure 13: SmartSaver's Full Missions.



(a) Mission Achieved Live Feedback.



(b) Mission Failed Live Feedback.

Figure 14: Live Missions Feedback.

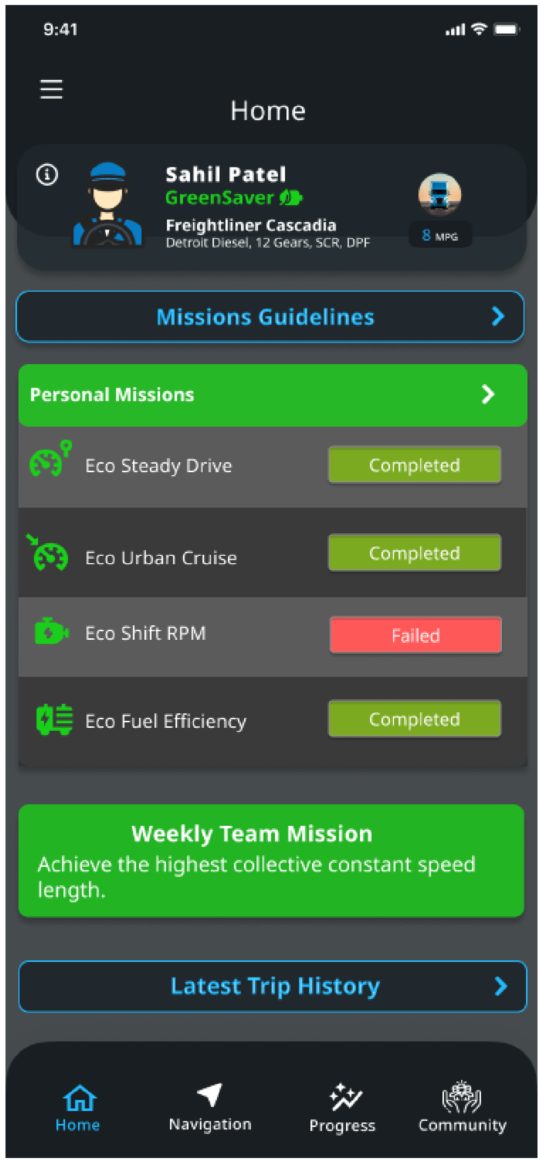


Figure 15: SmartSaver's Final Mission Completion.

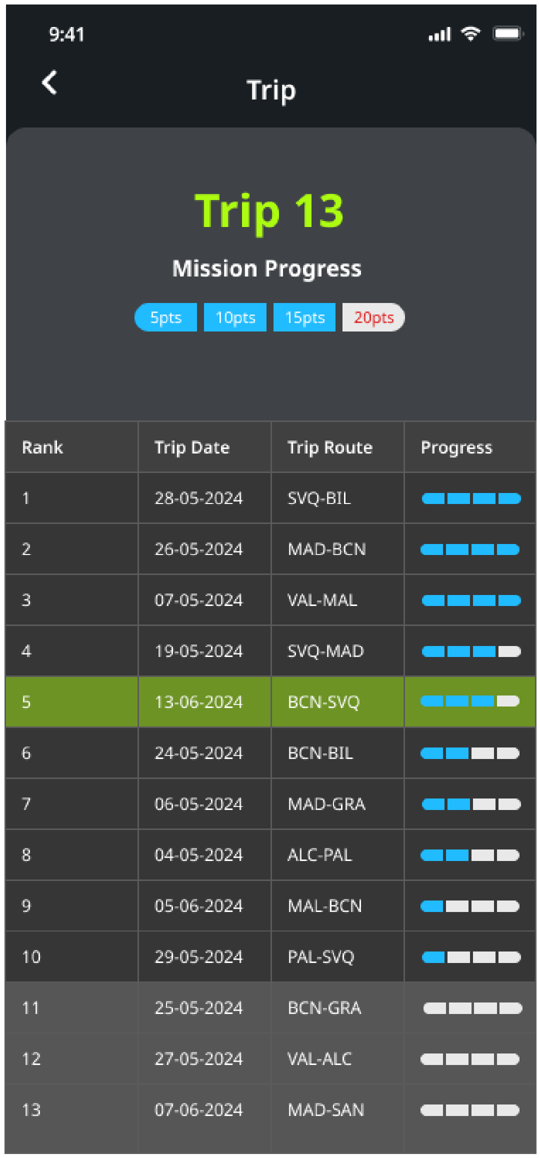


Figure 16: Post Trip Feedback.

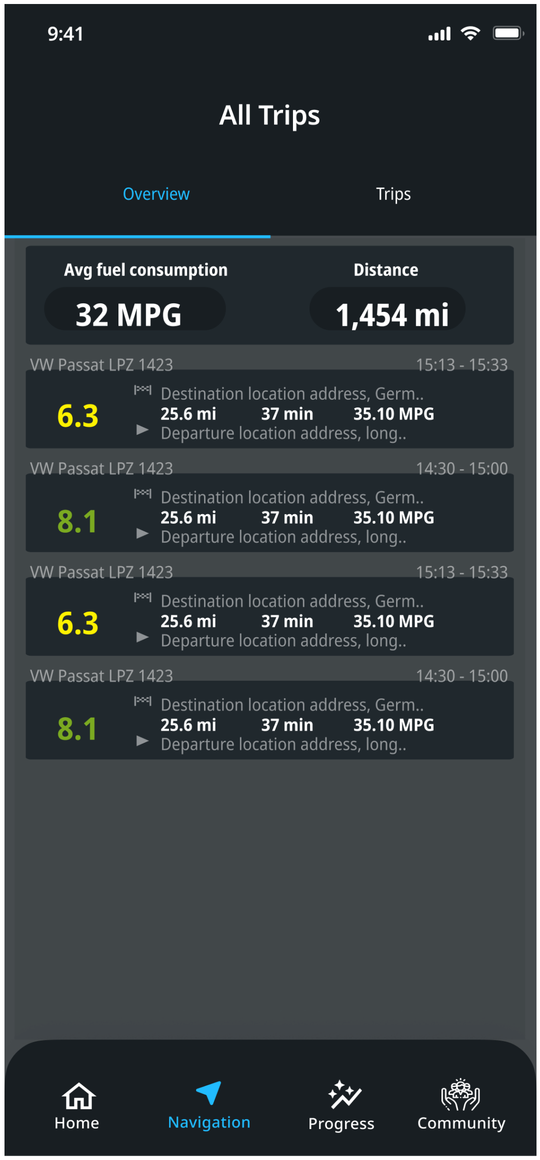


Figure 17: Previous Trips Feedback.

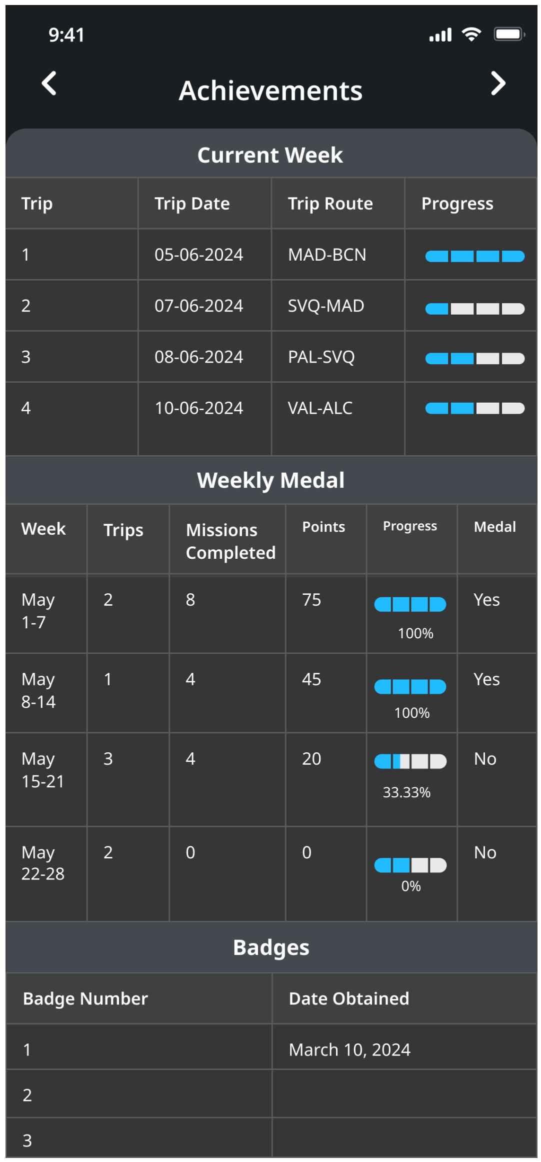


Figure 18: Weekly Achievements.

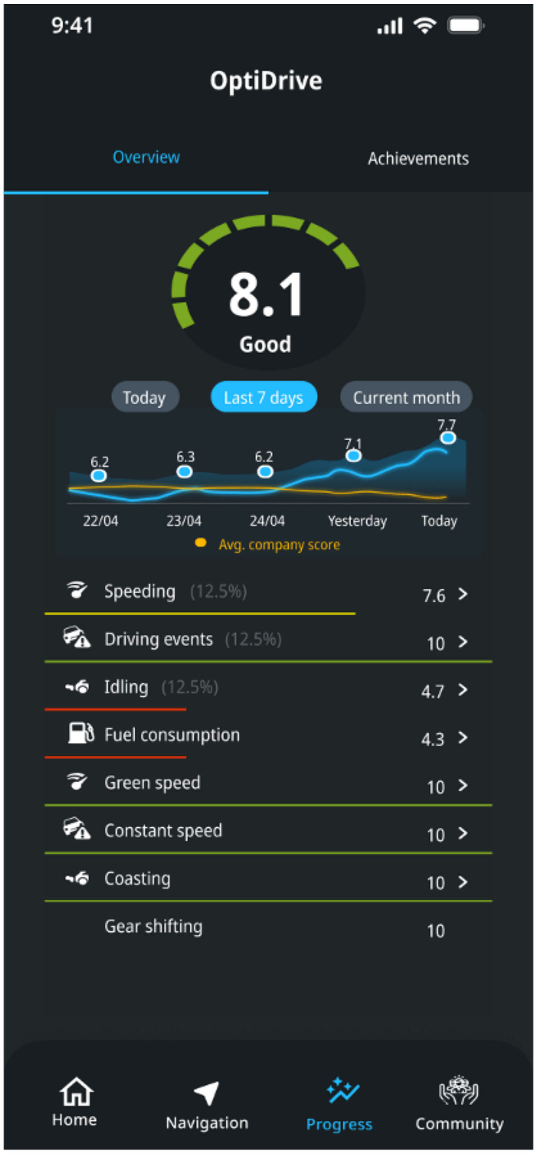


Figure 19: Actions Feedback.

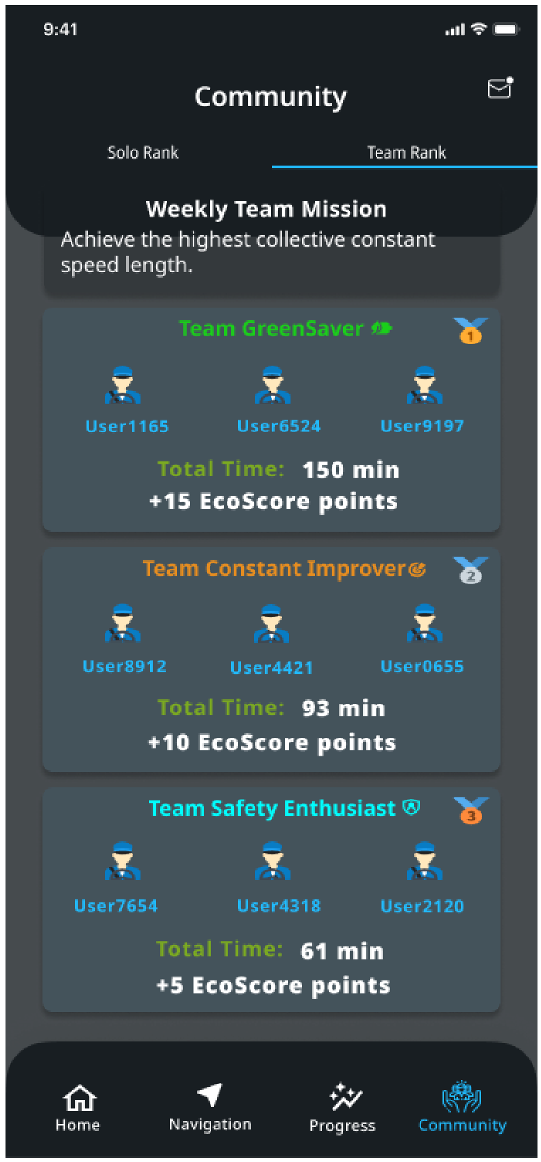


Figure 20: Team Rank Screen.

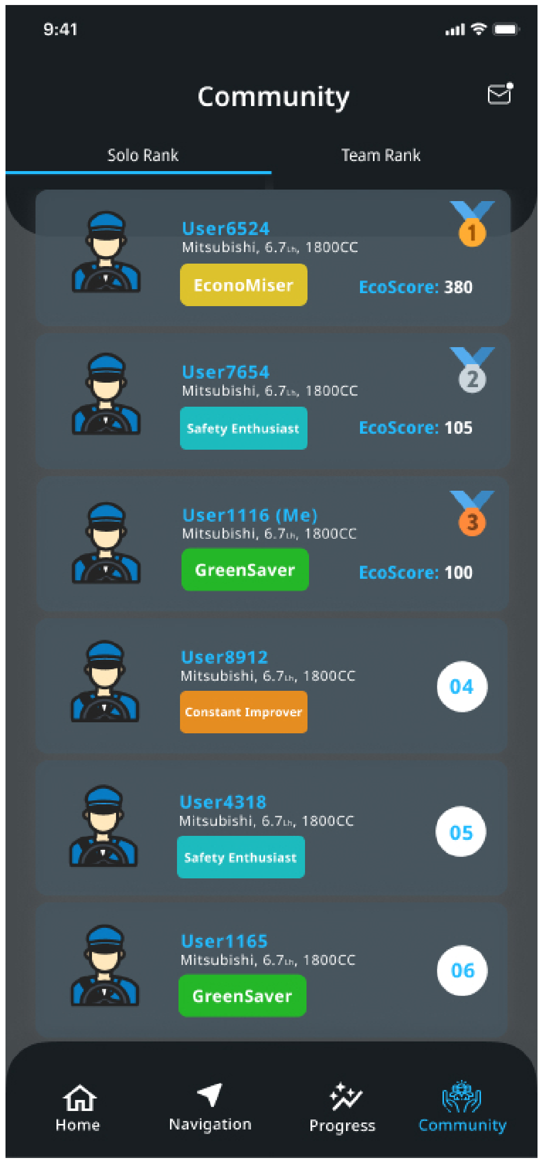
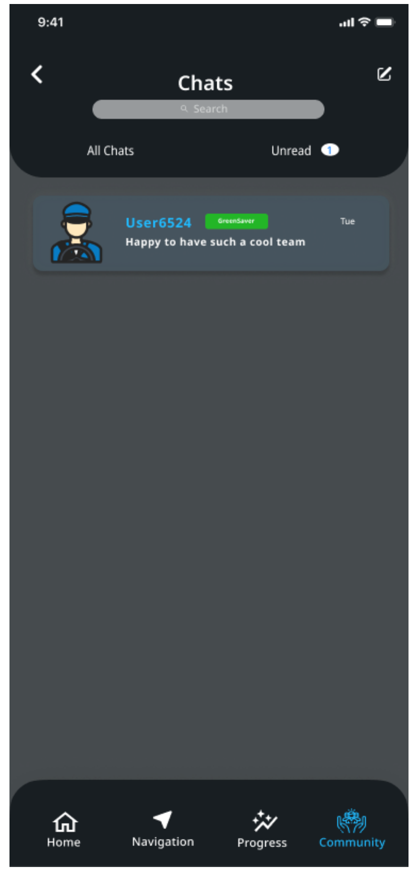


Figure 21: Solo Rank Screen.

(a) All Chats.



(b) Unread Chats.

Figure 22: In-app messaging.

2. Interactive Live Demo (5-10 minutes): Following the introduction, a live demonstration was performed. This demo highlighted the principal characteristics and capabilities of the prototype. Customers observed the product's real-time functionality, enabling them to develop more knowledgeable perspectives on its usability and performance.

3. Interview and Feedback Session (30 minutes): The main part of the session consisted of a 30-minute feedback interview. During the interview, customers were prompted to express their opinions, experiences, and suggestions regarding the prototype's functionality. The whole interview was recorded and transcribed with the *Notta* application [60] to guarantee that all input was precisely preserved for subsequent analysis. The recording were deleted shortly after the end of the interview, and only transcribed scripts were kept.

9 Analysis

The evaluation of the prototype's approach for encouraging long-lasting driving behaviour, based on observations from five interviews, exposes both favourable potential and important areas for improvement. Four main measures define the prototype's approach: intrinsic motivation, missions, feedback, and community. These elements are integrated into a gamified system designed to encourage eco-driving behaviors and maintain long-term engagement. Each interview offered unique insights into how these components are perceived by drivers and managers, underlining the importance of balancing initial engagement with sustained behavior change. This section evaluates the prototype's performance in relation to these core components, incorporates specific feedback from interviewees, and examines how the findings align with the proposed hypotheses.

9.1 Intrinsic Motivation and Personalised Profiles

The prototype's focus on intrinsic motivation via tailored driver profiles is a central feature. These profiles: GreenSaver, Constant Improver, EconoMiser, and Safety Enthusiast address varying intrinsic motives including fuel economy, personal growth, cost savings, and safety. Although the fundamental gamification components such as the scoring system and game rules are identical across all profiles, missions, and the kinds of rewards (e.g., badges, medals), differ to help accommodate the specific intrinsic motivations associated with each profile.

One important pattern in the interviews was the differences in opinion about the EconoMiser profile. While the first and second interviewees thought this profile is less relevant for most drivers arguing that drivers, especially in time-sensitive circumstances, tend to prioritise job efficiency over cost-saving, other interviewees, such the fifth, thought it was quite relevant. The fifth interviewee underlined the growing relevance of cost-efficiency in view of rising petrol prices and growing focus on sustainability. They even said they would personally choose the EconoMiser profile, implying that the profiles people find useful depends largely on both personal and professional settings.

Other profiles like the Safety Enthusiast and Constant Improver were more appreciated across interviews since they closely relate with important driving motivations like safety and personal development. This heterogeneity in profile choices emphasises the need of letting drivers choose profiles that fit their particular operational environments and motivations. This generally supports H_2, which states that personalised profiles match with personal drivers' inherent incentives hence help to sustain environmentally responsible behaviours.

Though personalised profiles and targeted gamification features are valuable, the interviews underlined that these approaches are still not sufficient to maintain long term interest in real-world surroundings. For instance, the third respondent noted that just over 10% of drivers are driven just by gamification components, such medals or leaderboard ranks. The interviewees consistently saw extrinsic rewards such as fuel bonuses, coupons, or lunch packages as crucial motivators to keep involvement over time. This implies that maintaining constant behaviour change depends on a mix between intrinsic and extrinsic motivators. The second interviewee also underlined the need of making sure missions are realistic since assigning impossible goals causes driver discontent and disengagement.

9.2 Missions and Achievability

The system's strength is its ability to customise missions depending on the individual profiles as it shows a deeper awareness of how various drivers are inherently motivated as noted by the participants. However, all five interviewees also underlined that retaining long-term involvement depends on customising missions to fit drivers' real-world environments and work obligations. This supports the Hypothesis H_2, which emphasises the need of mission relevance in encouraging long-lasting behaviours.

The first respondent pointed out the different operational settings between long-distance truckers and urban delivery drivers, underlining that missions need to consider these variations to stay effective and relevant. Similarly, the second respondent cautioned that assigning city drivers responsibilities tailored for highways could cause annoyance or even attempts to "game the system" through needless detours. Although the prototype emphasises intrinsic motivations, it also has to take practical reality into more account to maximise involvement and effectiveness.

The fourth respondent also recommended to include an initial training period, which can include in-person coaching or instructional videos, before drivers interact with the gamified components of the system. This can help to guarantee that drivers completely grasp what is required of them in terms of driving behaviours and system operation. Such instruction lays a better basis for involvement and long-term behavioural modification.

The fifth interviewee highlighted the competitive nature of the missions by comparing the system to video games such as *FIFA* [61], where statistics, rankings, and achievements inspire users to continually keep advancing. He noted that drivers motivated by quantifiable progress particularly find great attraction in competition, especially in the form of leaderboards and performance tracking. The interviewee also noted that most drivers in their company are men and thought they are more likely to interact with the competitive aspects of the system due to a wider preference of competitive gaming among the male audience. Nonetheless, regardless of gender, drivers who are inherently inclined toward ranking and performance criteria may find the competitive features of the system to be a motivating factor.

9.3 Feedback

The system's two primary forms of feedback: Real-Time Alerts and Post-Trip Analysis were well received but with some areas for improvement. The real-time alerts keep drivers informed during their trips, providing instant feedback on their progress for mission driving performance. Interviewees appreciated these real-time updates, noting their potential to complement existing solutions, such as WebFleet's real-time coaching, by adding more mission-specific feedback.

Though these real-time mission updates provide great value, some respondents expressed worries about the alert's UX design. Interviewees found the colour-coded alerts, green for task completion success and red for failing, to be possibly disruptive to the drivers. Moreover, drivers with colour blindness may find it difficult to effectively comprehend these signals. Interviewees advised design improvements potentially including haptic feedback or audible warnings to increase accessibility and safety.

The Post-Trip Analysis feature received more mixed comments. Although some interviewees valued the thorough reports that let drivers evaluate their performance and match their behaviour with mission objectives, others thought that if not simplified, all this feedback may become overwhelming. To prevent information overload, they advised emphasising only crucial concepts. Feedback also has to be timed correctly since too much information given in high-stress driving conditions can cause disengagement. For instance, the fifth interviewee underlined the significance of providing extensive feedback during downtimes that is, during breaks, instead of important times like navigating urban traffic, which aligns with the system's design of having real-time feedback and post-trip analysis.

The combination of Real-Time Alerts and Post-Trip Analysis was regarded as beneficial, reinforcing the idea in H_2 that personalized feedback is essential for fostering long-term eco-friendly behaviors. Overall, maintaining driver involvement and ensuring the long-term viability of the system also greatly depend on feedback timing and simplicity as seen from the interviews.

9.4 Community

The community element was consistently mentioned as a significant strength of the prototype whereby drivers can track their individual performance in solo rankings, check how their team did in weekly team missions via team ranks, and interact with one another via in-app messaging. Using leaderboards, team performance monitoring, and communication tools helps build a feeling of community, which all five interviewers said assists in maintaining involvement by using healthy peer pressure and team accountability. The third interviewee recounted a successful case from a big-scale driving competition where team performance inspired underperforming drivers to get better for the greater good of the group. This focus on teamwork and common objectives, instead of direct rivalry, was recognised as a good engine of involvement and performance enhancement. The second interviewee recommended adding cross-company comparisons to the leaderboard capability to improve the community element even more. Encouragement of drivers to evaluate their performance not only within their own fleet but also with colleagues from other fleets can help to increase community and competitive participation even more.

Notably, the first interviewee voiced worries about the probable negative effects of leaderboards. He gave an instance of an occurrence whereby public humiliation directed at under-performing drivers via leaderboards resulted in a toxic work environment. Drivers became resentful rather than motivated since they felt alienated instead. The respondent underlined the need of ensuring that leaderboards create a healthy, motivating culture instead of one that promotes public humiliation or competitiveness at the price of team spirit. The prototype design has taken this problem into account; leaderboards show just user IDs rather than names, therefore helping to protect anonymity. This reduces the possibility of public humiliation by means of the absence of a "face" to the driver in the system and the sole view of their name inside their Home profile.

Furthermore, interviewees had distinct opinions about the part managers should play in these community assets. While some interviewees, such as the first, thought that manager participation, through access to leaderboards and the capacity to send messages, can aid the creation of a supportive environment, others,such the fifth interviewee, firmly opposed manager involvement in the gamified system. He advised that this kind of participation can lead to a negative dynamic whereby drivers feel unduly under scrutiny. This difference in perspective reflects different employment conditions and emphasises the several ways managerial participation can affect driver engagement and team morale. This variability might thus rely on the specific context of the firm and might be another type of personalisation inside the system, suggesting that motivating elements are changed to fit the individual dynamics of every organisation.

9.5 Extrinsic Rewards and Long-Term Engagement

Every interview pointed out the need of extrinsic rewards for maintaining long-term involvement. Although the system's existing components like personalized profiles, gamification elements, community and feedback can initiate behavioural changes in drivers, interviewees underlined that maintaining long-term motivation depends on tangible rewards. The third interviewee described their experience planning a driving competition in which incentives like iPads greatly improved performance. Even small incentives like lunch packages or fuel vouchers were considered effective in keeping drivers committed over time.

Interviewees also suggested a tiered reward system. Under this approach, smaller prizes can be awarded for little achievements like hitting specific game benchmarks (for example earning a medal), while bigger awards can be kept away for larger successes (like earning 3 badges). Giving drivers continuous rewards as they traverse the system will help maintain involvement and interest.

In addition, the importance of integrating the system into the company's broader sustainability goals was also underscored. Without long-term commitment from management, drivers may lose interest over time. Regular rewards and recognition programs, tied to company-wide objectives like fuel savings or carbon emission reductions, would help ensure the prototype remains relevant and sustainable in the long run.

This feedback implies that drivers' opinions of gamification change with time and only partially support H_3. Although some drivers might shift their focus to intrinsic motivations such as personal development, for the majority extrinsic incentives remain essential. The interviews highlight the need of long-term involvement and behaviour modification depending on a balance between intrinsic and extrinsic motivators.

10 Results

Based on qualitative comments from five interviews, the following heatmap (Figure 23) graphically shows the evaluation of the four main characteristics of the prototype: intrinsic motivation, missions, feedback, and community. Red (low) to green (high) colour scheme used in the heatmap lets one easily grasp how each feature performed over the interviews. The evaluations are not arbitrary; they are directly linked to insights gained from the interview data, with scores assigned on a 0-5 scale to reflect the trends observed throughout the analysis. Python [62] and the Matplotlib library [63] were used to create the graph.

Intrinsic motivation received scored between 3.5 and 4.5 with an average score of 3.9. This is because, although some respondents raised worries about the relevance of the "EconoMiser" profile, especially for drivers in time-sensitive positions, the feedback on personalised profiles was generally positive.

Although the ability to customise missions based on driver profiles was appreciated, several interviewees underlined the need of making sure the missions were realistic and fit the real-world operational environments, consequently producing scores ranging from 3 to 4.5 with an average score of 3.7.

Real-time and post-trip combined feedback garnered more critical comments resulting in scores between 2.5 and 3.5 with an average score of 3.1. Although some participants valued immediate mission updates, others worried about the possibility of information overload and distraction while driving.

Community elements including team tasks and leaderboards were more highly regarded receiving ratings between 3.5 and 4.5 with an average score of 4.1. Though one participant voiced worries about the possibility for negative impacts, such as unhealthy rivalry, most interviewees valued the community elements for their positive capacity to encourage involvement.

With an overall average score of 3.7, the prototype was clearly well accepted. With a 4.1 average score, the Community feature sprang out; followed by Intrinsic Motivation at 3.9. Missions got a score of 3.7, while Feedback earned the lowest average score of 3.1, suggesting space for development in the user experience and information delivery. Although the prototype performs well on numerous aspects, the overall results imply that more improvements, especially in the feedback and mission alignment, are required to increase its long-term impact and user involvement.

Suppose that we want to cut fuel use by 10%. Based on the studies on eco-driving methods and fleet management systems mentioned below, this is a reasonable and attainable goal. Studies repeatedly show that changing more fuel-efficient driving habits such as lowering harsh acceleration, minimising idle time, and speed consistency can result in fuel savings ranging between 5% and 20%.

For example, a European Commission study revealed that depending on the degree of involvement of the driver and the type of vehicle, eco-driving techniques might cut fuel use by 5–15% [64]. Comparatively, tests done by the U.S. Department of Energy found that fuel-efficient driving techniques might decrease gasoline use for bigger cars by roughly 15% to 30% at highway speeds and 10% to 40% in stop-and-go traffic [65].

This information enables us to project a 10% fuel use reduction by employing the prototype with its custom profiles, real-time feedback, mission-based goals, and community interaction. Though every driver profile in the prototype such as the EconoMiser, GreenSaver, Constant Improver or Safety Enthusiast focuses on various intrinsic motives and customised tasks, all of these profiles are ultimately targeted at encouraging eco-friendly driving practices. While the personalising improves driver involvement by satisfying individual preferences, the activities advised by the application such as cutting idle, optimising routes, and driving at optimal speeds all help to achieve the same goal: lower fuel consumption and CO_2 emissions.

To estimate the potential fuel savings based on the prototype's suggestions, we assume the following parameters:

- Number of drivers: 500
- Daily distance driven per driver: 100 km
- Fuel consumption rate (for larger vehicles like trucks/vans): 13 liters per 100 km
- Fuel cost: 1.52 euros per liter
- Estimated fuel consumption reduction: 10%

The total annual fuel savings for 500 drivers, considering a 10% reduction in fuel consumption, is given by the equation:

$$\textbf{Total Annual Savings} = \text{Number of Drivers} \times (\text{Fuel Cost per Driver} \times \text{Fuel Savings Percentage}) \quad (1)$$

So we solve for the equation by performing the following steps:

$$\textbf{Annual Distance per Driver} = 100\text{km/day} \times 365\text{days/year} = 36,500\,\text{km/year} \quad (2)$$

$$\textbf{Fuel Consumed per Driver} = \frac{13\,\text{liters}}{100\,\text{km}} \times 36,500\,\text{km/year} = 4,745\,\text{liters/year} \quad (3)$$

Figure 23: Feature Success Heatmap.

$$\textbf{Annual Fuel Cost per Driver} = 4,745 \text{liters/year} \times 1.52\,\text{euros/liter} = 7,214.4\,\text{euros/year} \quad (4)$$

$$\textbf{Savings per Driver} = 0.10 \times 7,214.4 \text{euros/year} = 721.44\,\text{euros/year} \quad (5)$$

$$\textbf{Total Annual Savings} = 500 \times 721.44 \text{euros/year} = 360,720\,\text{euros/year} \quad (6)$$

The calculation for fuel savings shows the real influence the prototype can have if its features are implemented effectively. Through customised profiles, real-time feedback, community and mission-based goals, the prototype has the potential to lower fuel usage by 10%, therefore translating into major yearly savings of 360,720 euros for a fleet of 500 drivers. This emphasises the financial and environmental worth of the system and supports the need of continuously improving the feedback and mission alignment to maximise its long-term performance.

11 Conclusion

The goal of this thesis was to test whether a combined approach prototype has the potential to motivate commerical drivers to internalize eco-driving behaviors as part of their self-concept, thereby generating long-lasting change. In conclusion, by use of a mix of intrinsic motivation, customised missions, feedback, and community involvement, the prototype offers promising means of encouraging long-term eco-driving behaviours. Though the study shows room for improvement for the prototype to attain more success, each of these fundamental elements is important in understanding and influencing driver behaviour. Keeping drivers engaged relies heavily on personalised profiles and missions, but it's crucial that these are carefully tailored to ensure they are both relevant and achievable within real-world constraints.

Moreover, feedback system has to be made more user-friendly as it is one of the most essential components of the strategy. For instance, numerous respondents voiced worries about information overload and distractions while driving, which can be mitigated with simplifying the feedback and making it more intuitive.

The study shows that leveraging social dynamics and peer pressure, the community element of the prototype, especially the utilisation of team-based challenges and leaderboards, has the potential to significantly boost drivers' engagement. Nevertheless, as the study points out, effort has to be made to ensure that competitiveness stays inclusive and constructive, therefore preventing negative implications like public humiliation.

Although gamification and intrinsic motivation aspects are beneficial for a limited group of drivers, most will need extrinsic incentives to remain involved over the long run. Using a tiered reward system, with bigger rewards for sustained behaviours and smaller incentives for shorter-term objectives, can help to better meet drivers' desire for real benefits. Combining such incentives with the present system allows it to create a more effective system for maintaining long-lasting ecologically friendly driving practices.

These advancements enable the prototype to not only involve drivers temporarily, but also promote continuous change in behaviour benefiting the businesses they serve as well as the drivers themselves. By matching driver intrinsic behaviours with corporate sustainability objectives, the technology can ultimately help more general environmental goals including reductions in fuel use and CO_2 emissions.

12 Future Works

To further assist in developing a sophisticated system, the next step should be to incorporate the feedback from the five interviews conducted in the existing study. Once these changes are underway, the emphasis will move to actually testing the prototype with drivers, therefore enabling the target audience's feedback. This practical testing will give a more accurate evaluation of the system's efficacy by offering data on how well it operates in daily driving situations.

From a technical aspect, the future effort also includes developing the prototype outside of its conceptual design and implementing the prototype in code to evaluate what technical possibilities are practical. This will cover verifying the system's capacity to generate customised missions, manage real-time data processing, and properly combine feedback systems. During this phase it is necessary to assess where technical limits arise and which aspects can be effectively used with existing technologies. This technical development stage will enable the prototype's scope to be improved and any discrepancies between the conceptual objectives and practical implementation found.

To further support the system empirically, it might be useful to gather demographic data on the drivers using the survey provided in Appendix C. This will help identify patterns in driver behavior, preferences and susceptibility, enabling more personalised interventions. Furthermore, future research should look at how these gamification elements operate across different target audiences such as female drivers. While the present prototype mostly targets male drivers who represent the majority of the fleet, it can be interesting to investigate whether the same characteristics appeal to and work on female drivers. Although the number of female drivers in the sector is small, it can be also tested whether it is needed to modify the system for this group or if the focus should remain on the male audience.

Future studies can also look at how intrinsic factors, such as competitiveness against cooperation, affect driver long-term involvement. Moreover, it can be interesting to explore how artificial intelligence can aid at delivering tailored feedback and/or missions. Another key element for future research is conducting a longitudinal research observing drivers' behaviour over an extended period in order to test the system's ability to evoke long-term commitment.

In summary, the future projects should not only confirm the technical and pragmatic efficiency of the prototype but also provide opportunities for additional innovation, consequently improving the adaptability and influence of the system.

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A Appendix: Consent Form

Interview Consent and Privacy Form

Purpose of the Study

You are invited to participate in a research study aimed at evaluating the impact of gamification techniques on driving behavior.

Procedures

If you agree to participate in this study, you will be asked to take part in a walk-through of the prototype, followed by a 30-minute interview. The interview will be recorded and transcribed for data analysis purposes.

Privacy and Confidentiality

Your participation in this study is voluntary. The recordings will be deleted after the transcription and only the transcribed version will be used for the analysis. All information collected will be kept confidential, and used solely for research purposes. Any identifiable information will not be stored in the final report. This study adheres to the privacy rules and regulations set forth by *Utrecht University* and compliant with *GDPR.*

Participant Rights

According to GDPR, you have the following rights:

- The Right to Information
- The Right of Access
- The Right to Rectification
- The Right to Erasure
- The Right to Data Portability
- The Right to Object
- The Right to Avoid Automated Decision-Making

If you have any questions about your rights as a participant in the research or if you have any concerns or complaints about the way in which the participants in the research are treated, you can send an email to the privacy officer of Utrecht University: privacy@uu.nl .

If you have any questions, comments, or concerns regarding this research project, please contact Dr. Sergey Sosnovsky: s.a.sosnovsky@uu.nl

This survey is conducted as a part of the MSc thesis in Game and Media Technology of Elena Negasheva (e.negasheva@students.uu.nl), supervised by Dr. Sergey Sosnovsky.
Date: 21/06/24

Informed Consent

1. I have read and understood the information for the participant (Right to Information). I had enough time and information to decide whether to participate. If I have questions, I know whom to contact.
2. I know that participation in this experiment is completely voluntary. I am aware that I can decide at any time to stop participating (Right to Object) and have my data erased (Right to Erasure). I do not have to give a reason for that.
3. I know that the researchers conducting this experiment can see my data in anonymized form. The names and contact details of these people are known to me. I have the right to view the way in which my data is stored and processed (Right to Access). If the data is erroneous or incomplete, I am entitled to have it corrected (Right to Rectification). I can also request to get access to it for my own purpose (Right to Data Portability).
4. At no point, I am at risk of potentially damaging decisions due to automated decision making and profiling based on my data (Right to Avoid Automated Decision-Making).
5. I give permission to use my data for the purposes stated in the information letter.
6. I give my permission to keep the data for another 10 years after the end of this study for further analysis in the context of this study (if necessary).

Participant Consent

I have read and understood the information provided above. I voluntarily agree to participate in this study and consent to the recording of the interview.

Participant's Consent: ☐ I agree

Researcher's Declaration:

I hereby declare that I have sufficiently informed this participant about this study. If information becomes known during the study that could influence the consent of the participant, I will inform him/her in a timely manner in a way that ensures that the information has reached the participant.

Date: ______________________________

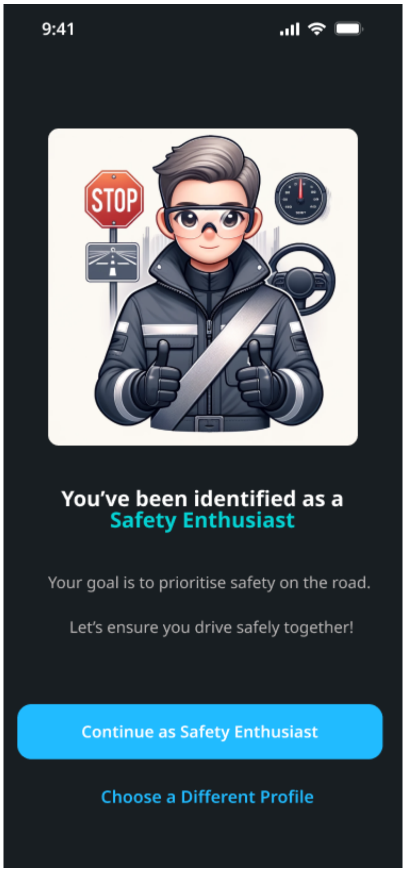
Thank you for your participation in this study. Your feedback is invaluable to our research.

B Appendix: App Secondary Screens

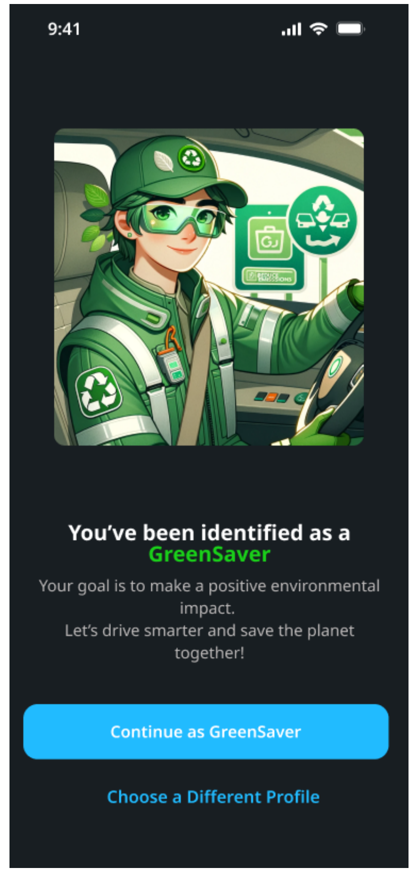
(a) GreenSaver.

(b) Safety Enthusiast.

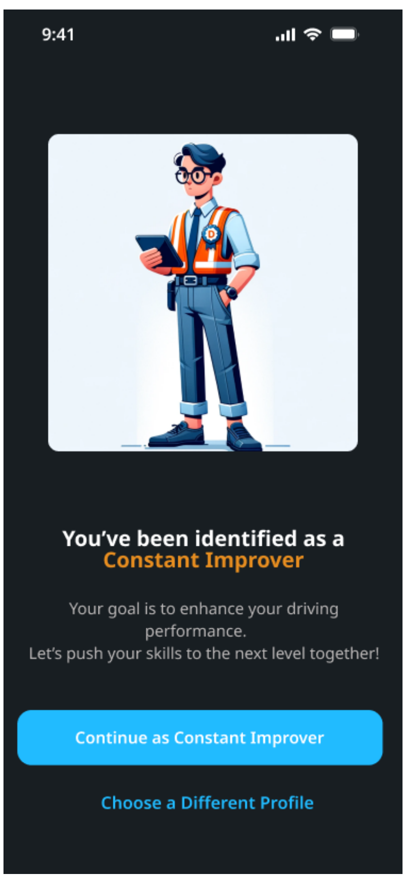
Figure 24: Game Rules.



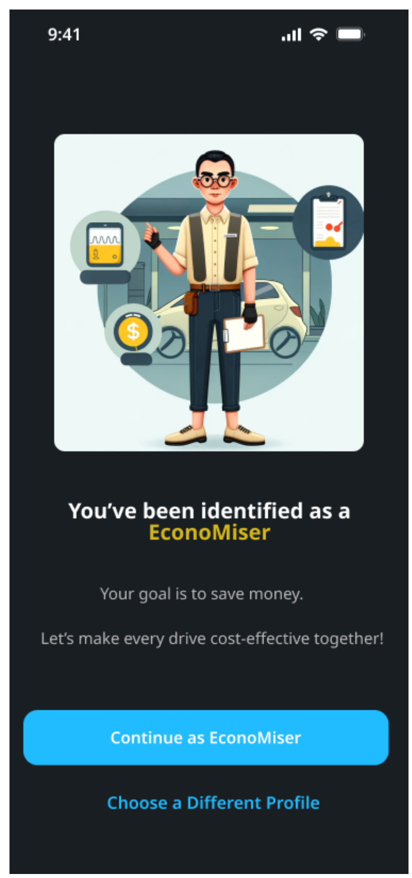
(a) Safety Enthusiast Profile



(b) Smart Saver Profile



(c) Constant Improver Profile



(d) EconoMiser Profile

Figure 25: Initially Assigned Drivers' Profiles

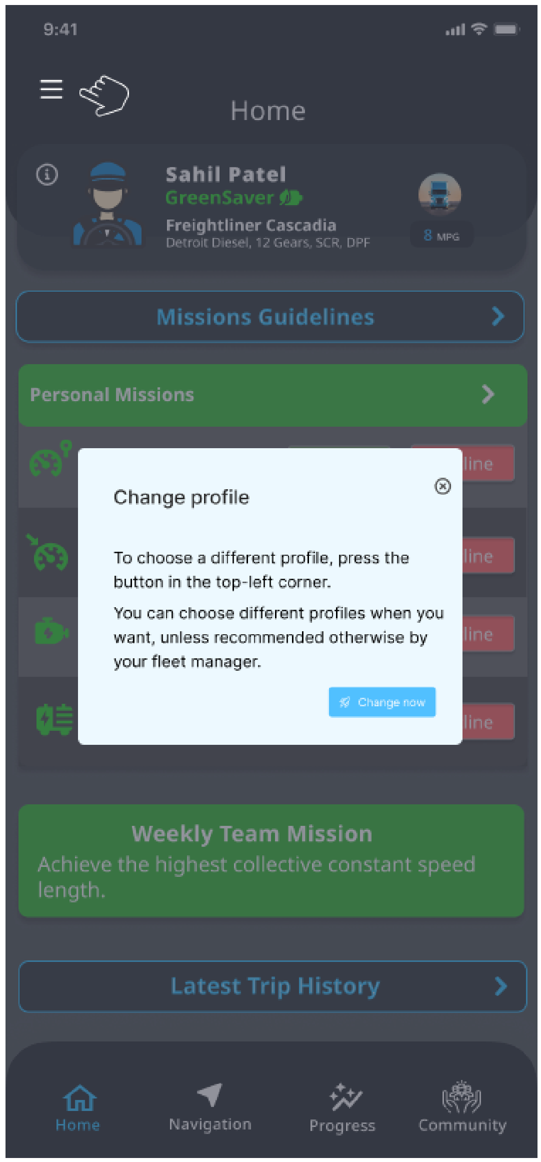
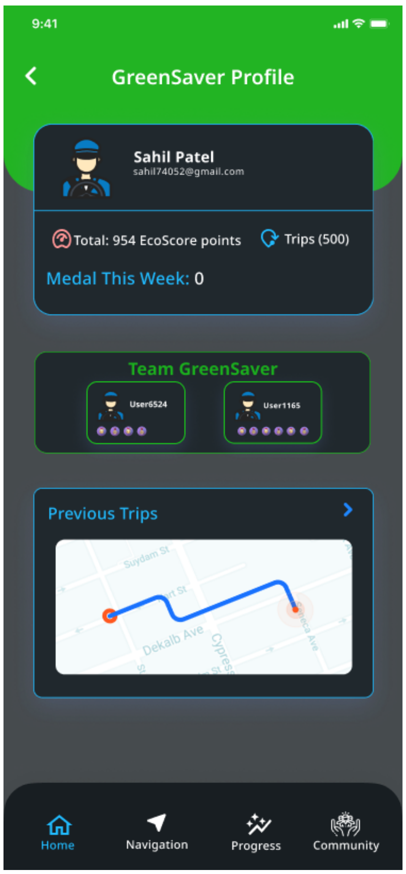
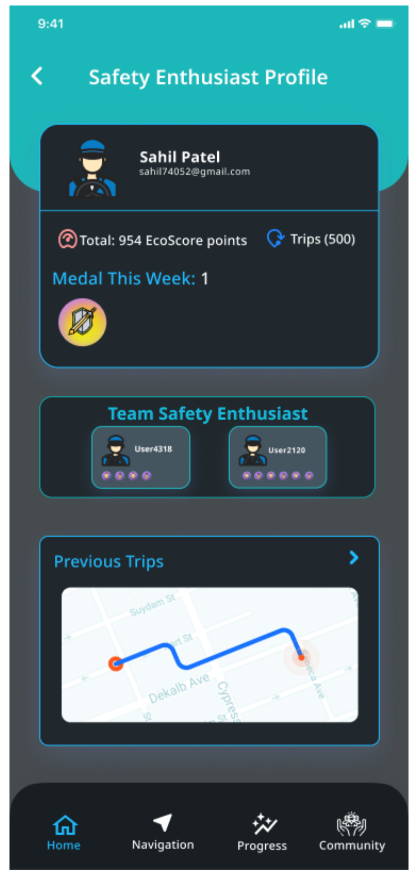


Figure 26: Profile Switch Choice Notification.

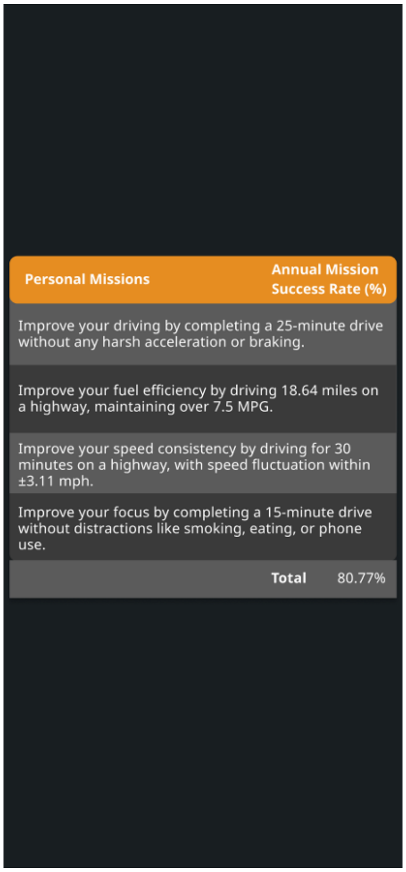


(a) GreenSaver Profile Details.

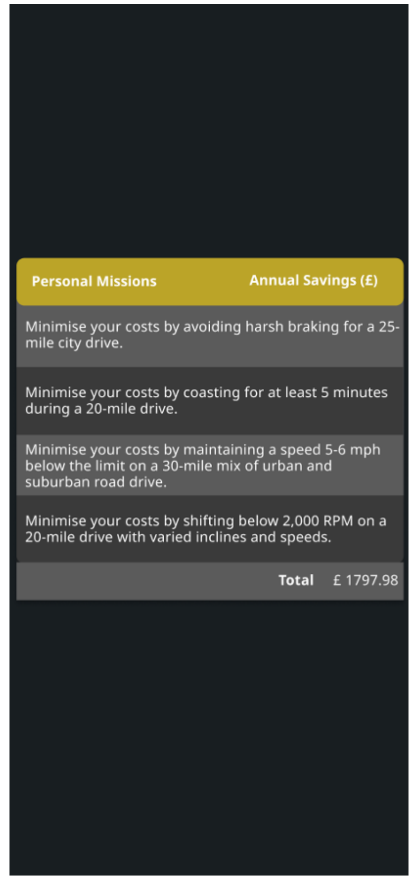


(b) Safety Enthusiast Profile Details.

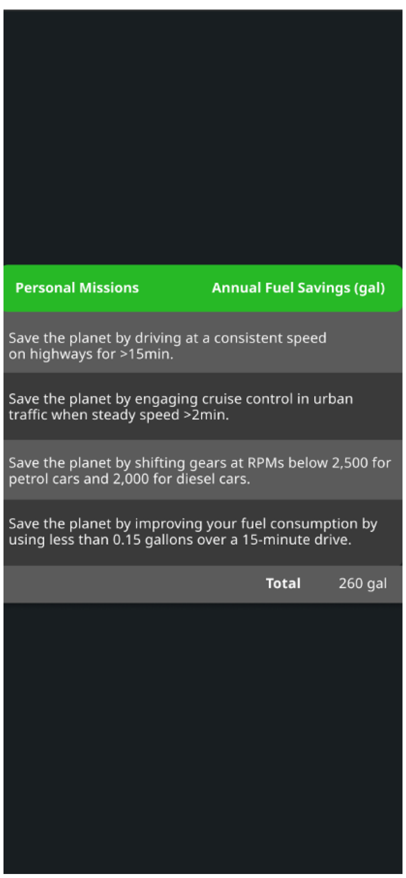
Figure 27: Profiles' Details.



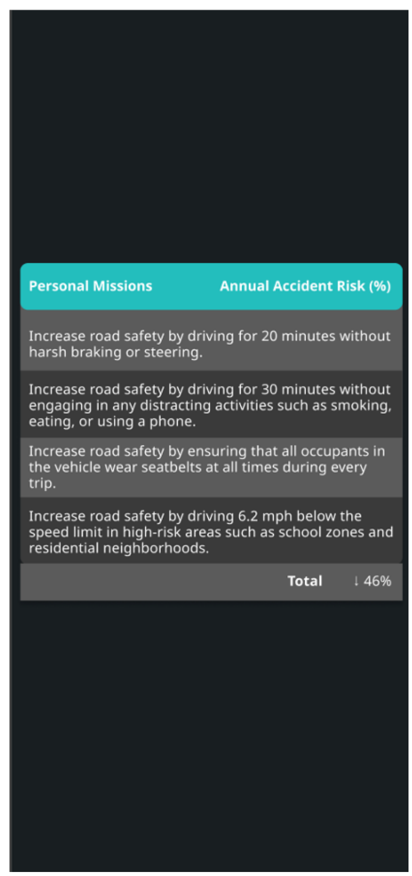
(a) Constant Improver Missions



(b) EconoMiser Missions



(c) GreenSaver Missions



(d) Safety Enthusiast Missions

Figure 28: Profiles' Detailed Missions.

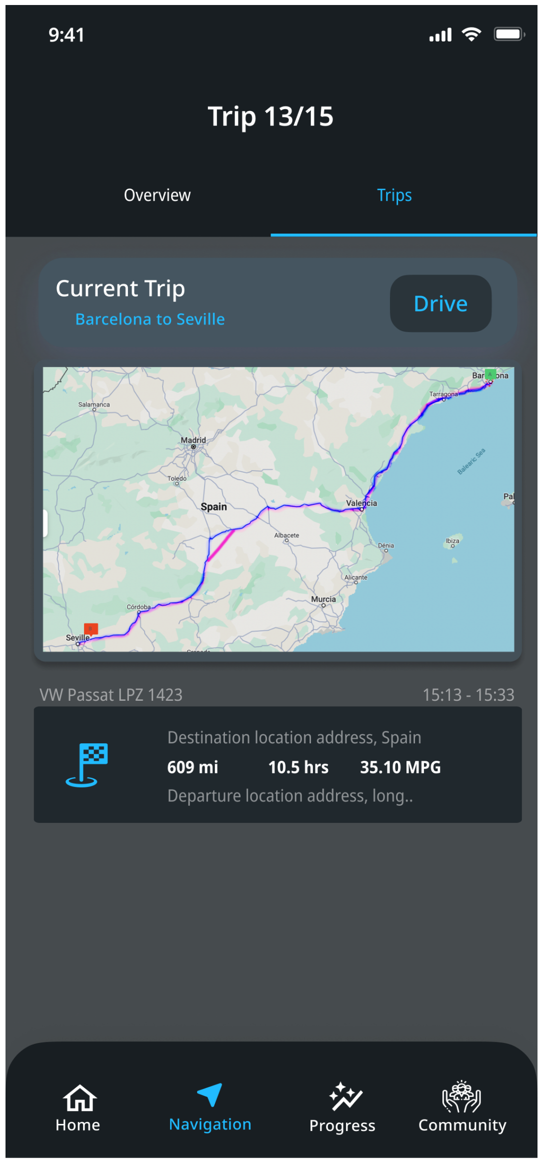


Figure 29: Pre-trip Route Screen.

C Appendix: Drivers' Survey

Thank you for taking the time to participate in this survey. We're interested in how truck drivers like you can drive in a way that helps the planet. Please choose the answers that best fit your situation.

Estimated Completion Time: This survey should take about **10 minutes** to complete.

Privacy: Your answers are private, and we will **NOT** share them. The data will be used **only** for research purposes.

Agreement: If you want to stop, it's okay. By continuing, you agree to these terms.

1. **Gender:**
   - ☐ Male
   - ☐ Female
   - ☐ Other
   - ☐ I don't want to say

2. **Age:**
   - ☐ Under 25
   - ☐ 25-34
   - ☐ 35-44
   - ☐ 45-54
   - ☐ 55-64
   - ☐ 65 or older

3. **Where are you from?**______________________________________

4. **How long have you been a truck/van driver?**
   - ☐ Less than 1 year
   - ☐ 1-5 years
   - ☐ 6-10 years
   - ☐ More than 10 years

5. **What kind of vehicle do you drive?** (Pick all that fit)
   - ☐ Long-distance trucks/vans
   - ☐ Trucks/Vans for local deliveries
   - ☐ Specialized trucks (like refrigerated or tanker)
   - ☐ Other (please write): ______________________________________

6. **How far do you drive in a week (in miles)?**
   - ☐ Less than 300 mi
   - ☐ 300-600 mi
   - ☐ 600-900 mi
   - ☐ 900-1,200 mi
   - ☐ More than 1,200 mi

7. **How much do you know about driving in a way that helps the planet?**
   - ☐ 1 (I don't know much)
   - ☐ 2 (I know a little)
   - ☐ 3 (I have some knowledge)
   - ☐ 4 (I know quite a bit)
   - ☐ 5 (I know a lot)

8. **How often do you drive to help the planet?**
   - ☐ 1 (Never)
   - ☐ 2 (Rarely)
   - ☐ 3 (Sometimes)
   - ☐ 4 (Often)
   - ☐ 5 (Always)

9. **What things do you do regularly, if any? (Pick all that fit)**
   - ☐ Taking care of tires
   - ☐ Not keeping the engine on when stopped
   - ☐ Driving at constant speed when possible
   - ☐ Avoid harsh braking
   - ☐ Regular vehicle maintenance
   - ☐ Other (please write): ______________________________

10. **Has your boss ever taught you about driving in a way that helps the planet?**
    - ☐ Yes
    - ☐ No

11. **How open are you to try things that help the planet when driving?**
    - ☐ 1 (Not open at all)
    - ☐ 2 (Slightly open)
    - ☐ 3 (Moderately open)
    - ☐ 4 (Quite open)
    - ☐ 5 (Very open)

Using the scale provided, indicate your level of agreement by circling the appropriate number: 1 signifies 'Not at all likely', and 5 represents 'Very likely.'

12. **Learning eco-driving through fun games makes it easier for me to remember how to do it.**

    1 2 3 4 5

13. **Getting points/medals for driving well makes me want to do it more.**

    1 2 3 4 5

14. **Knowing how my eco-driving performance compares to my peers motivates me to drive better.**

    1 2 3 4 5

15. **Collaborating with other drivers in team missions would make my eco-driving journey more enjoyable.**

    1 2 3 4 5

16. **I am more likely to follow eco-driving if it matches my values and interests.**

    1 2 3 4 5

17. **I believe that eco-friendly driving habits I learn now will stick with me in the long run.**

    1 2 3 4 5

18. **Having a way to track my driving improvements over time would help me stick with good habits.**

    1 2 3 4 5

19. **Participating in challenges or missions related to eco-driving would make the experience more engaging for me.**

    1 2 3 4 5

20. **I feel a sense of pride and ownership when I achieve milestones in a game.**

    1 2 3 4 5

Do you have any other thoughts about driving in a way that helps the planet?

Thank you for answering our survey! Your answers will help us understand how truck drivers like you can drive in a way that helps the planet. Your answers are very important.