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How Does Gamification in Eco-Driving Influence Consumer Behavior?

MSc Thesis
DEPARTMENT OF BUSINESS AND MANAGEMENT

SUSTAINABILITY FOR MARKETING

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I am deeply grateful to Professor Alessandro Maria Peluso for his invaluable support, guidance and encouragement throughout my thesis. I dedicate this thesis to Professor Alessandro Maria Peluso and to my childhood friend Mücahit Taha Az.

Abstract

This thesis focuses on how gamification impacts on consumer motivation, attitude and behavior change for eco-driving. With rising environmental awareness, eco-driving becomes a behavioral approach for fuel consumption reduction, however it is also known that its adoption by end-users is difficult to convince. To the best of our knowledge, most of these questions remain unanswered; therefore, we aim to fill this gap by examining the psychological processes underlying how gamification can promote sustainable driving.

The study adopted a quantitative, survey-based experimental design to establish the causal effect of the game-induced scenario and compare it with a control informational (non-gamified) condition on participants' attitudes and behavioural intentions. Based on the Technology Acceptance Model (TAM), the research considers core constructs of perceived usefulness, perceived enjoyment, motivation and intention to engage in using eco-driving behavior. Such results pursue the objective of offering practical advice to car manufacturers, mobile app developers and environmental decision-makers helping to achieve a sustainable transport structure.

List of Abbreviations

LD   Leaderboard

ECO   Eco Driving

EC   Environmental

FB   Feedback

Chapter 1

Introduction

1.1 Chapter Overview

This chapter of this research explains the background and context of the study and subsequently the problem statement, aims of the study, research questions, and research hypothesis. Additionally, a preliminary description of the importance of the study is given along with its scope and delimitations. The definitions of the most important terms used are mentioned to avoid any misinterpretations. It ends with an overview of the organization of the thesis, along with a summary of all the details mentioned in this chapter.

1.2 Background and Context

Tackling global climate change requires innovative strategies to encourage sustainable behavior and gamification has been identified as a promising tool for environmental protection. The transportation sector is a significant source of global carbon dioxide (CO_2) emissions, contributing approximately 27% of total greenhouse gas emissions in the United States in 2020 (U.S. Environmental Protection Agency, 2022) and accounting for a substantial portion of global energy-related emissions (International Energy Agency, 2021). This makes it a critical area for intervention. While technological solutions like electric vehicles are vital, a vehicle's actual environmental performance is heavily influenced by driver behavior (Barkenbus, 2010).

This highlights the importance of "eco-driving," a collection of driving techniques designed to minimize fuel consumption and emissions such as avoiding sudden acceleration and braking (Beusen et al., 2009). As a form of Pro-Environmental Behavior (PEB), eco-driving holds significant potential for positive environmental impact, with studies demonstrating fuel savings that can range from 5% to 25%

(Ciuffo et al., 2011). However, altering the deeply ingrained and often automatic habits of drivers presents a substantial behavioral hurdle. Driving is a highly proceduralized behavior, frequently performed without conscious deliberation, making it resistant to change (Verplanken & Aarts, 1999; Norman, 2002). Consequently, traditional informational campaigns often fall short in fostering lasting behavioral shifts, pointing to a need for more engaging and effective motivational methods (Abrahamse & Steg, 2013).

Gamification has emerged as a powerful strategy to address this challenge. It is formally defined as "the use of game-design elements in non-game contexts" (Deterding et al., 2011). In the context of eco-driving, the objective of gamification is to transform the potentially mundane task of energy conservation into an experience that is more enjoyable, engaging, and rewarding for the driver (Morganti et al., 2017). By leveraging game elements such as points, badges, and leaderboards, these systems provide immediate feedback and social incentives, making the invisible results of efficient driving visible and rewarding (Looyestyn et al., 2017). This approach aims to foster both intrinsic and extrinsic motivation, thereby encouraging the adoption and maintenance of eco-driving habits where informational approaches alone have proven insufficient (Johnson et al., 2016), fostering sustained behavioral change.

1.3 Problem Statement

The central problem this thesis addresses is the "performance-adoption trade-off" in gamified eco-driving systems, a critical issue largely overlooked in the existing literature. While gamification shows promise in promoting pro-environmental behaviors, current research has primarily focused on whether it works, rather than under what conditions it is sustainable. A pivotal field experiment by Degirmenci and Breitner (2023) revealed that while more intrusive feedback (e.g., auditory alerts for poor driving) significantly improved eco-driving performance (an instrumental outcome), it also made the application significantly less enjoyable and lowered users' intention for future use (a negative experiential outcome).

This finding is critical because the long-term effectiveness of any gamified system becomes meaningless if users abandon it due to a frustrating or unenjoyable experience. This issue highlights the "novelty effect," where the initial appeal of a gamified system fades over time if it fails to generate sustainable, intrinsic motivation.

Therefore, the research problem extends beyond simply asking if gamification can encourage eco-driving. The core challenge is to identify which gamification design strategies can create sustainable intrinsic motivation for eco-driving without sacrificing long-term user adoption and engagement. The true measure of a system's real-world impact is not just its ability to save energy momentarily, but also the duration and willingness of users to engage with it over time. This thesis aims to understand this critical trade-off and develop evidence-based design principles to resolve it.

1.4 Research Objectives

The primary aim of this thesis is to systematically investigate the effects of leaderboards, a competitive gamification strategy on both drivers' instrumental outcomes (energy efficiency) and experiential outcomes (intrinsic motivation, perceived enjoyment, adoption intention). The research aims to explain *how* and *why* leaderboards work by analyzing the underlying psychological mechanisms and individual differences.

To achieve this overall aim, the study will pursue the following specific objectives:

1. **To Investigate the Impact of Leaderboards on Instrumental and Experiential Outcomes:** To empirically measure the effect of a leaderboard-based system on drivers' eco-driving performance (instrumental outcome) while simultaneously evaluating its impact on perceived enjoyment, intrinsic

motivation, and future intention to use (experiential outcomes). This will allow for a direct examination of the performance-adoption trade-off in a competitive context.

2. **To Examine the Effect of Leaderboards on Psychological Needs:** To analyze the impact of competing on a leaderboard on the satisfaction of basic psychological needs as defined by Self-Determination Theory. This analysis will focus specifically on the needs for **competence** (feeling effective and skillful) and **autonomy** (feeling a sense of choice and volition).

3. **To Assess the Moderating Effect of Social Comparison Orientation:** To determine how the motivational impact (both positive and negative) of a leaderboard is moderated by the driver's individual personality trait of **Social Comparison Orientation**. Specifically, to test the hypothesis that individuals more prone to comparing themselves to others will show a stronger reaction to their rankings.

4. **To Develop Evidence-Based Design Principles for Leaderboards:** To translate the empirical findings into specific and actionable design guidelines for implementing leaderboards in pro-environmental applications. These principles will aim to maximize motivational benefits while mitigating potential negative psychological effects, such as demotivation for users in lower ranks.

1.5 Research Questions

It is critical to understand not only *if* leaderboards can improve eco-driving performance but also *how* they achieve this and *for whom* they are most effective. Leaderboards are not a standalone solution; their success is contingent on their ability to satisfy basic psychological needs, such as the drive to feel competent and in control (Deci & Ryan, 2000). A design that undermines these needs could lead to user disengagement, regardless of short-term performance gains. This issue has been

identified in the literature as the "performance-adoption trade-off," where it has been empirically shown that more intrusive gamification elements can negatively impact user experience and long-term adoption (Degirmenci & Breitner, 2023).

Furthermore, the motivational impact of social competition is not uniform across all individuals. The natural tendency of individuals to compare themselves with others (Festinger, 1954) plays a crucial role in their responses to competitive environments. Therefore, this study also aims to understand how a driver's inherent social comparison orientation (Gibbons & Buunk, 1999) might amplify or diminish the effectiveness of a leaderboard.

The following research questions were created to direct the study:

1. What is the effect of a leaderboard on a driver's eco-driving performance (instrumental outcome) compared to its effect on their perceived enjoyment and intention to continue using the system (experiential outcomes)?

2. How does competing on a leaderboard influence the satisfaction of a driver's basic psychological needs for **competence** and **autonomy**?

3. How does a driver's **Social Comparison Orientation** (low vs. high) moderate the relationship between their rank on a leaderboard and their resulting motivation and engagement?

1.6 Research Hypothesis

H1 (The Performance-Adoption Trade-Off Hypothesis): This hypothesis addresses the primary conflict between task performance and user engagement.

- **H1a:** Participants in the competitive leaderboard group will demonstrate significantly higher eco-driving performance (i.e., lower energy consumption) compared to a control group with no gamified feedback.

- **H1b:** The performance gains observed in the leaderboard group will be accompanied by significantly lower perceived enjoyment compared to a group receiving non-competitive, task-based feedback.

  - **Rationale:** This hypothesis directly tests the **performance-adoption trade-off**. While the competitive pressure of a leaderboard is expected to improve instrumental outcomes (performance), it may simultaneously generate negative experiential outcomes by making the task less enjoyable, which could harm long-term adoption.

H2 (The Psychological Needs Hypothesis): This hypothesis examines the underlying psychological mechanisms through which leaderboards affect motivation, based on Self-Determination Theory (SDT).

- **H2a:** A driver's rank on the leaderboard will positively influence their satisfaction of the need for **competence**. Higher rankings will lead to higher competence satisfaction, while lower rankings will lead to lower competence satisfaction.

- **H2b:** Competing on a leaderboard will negatively influence the satisfaction of the need for **autonomy**.

  - **Rationale:** While achieving a high rank can affirm a user's skill and satisfy the need for competence, a leaderboard imposes an external standard of success that can feel controlling. This external pressure can undermine a driver's sense of autonomy, making them feel as though their actions are being judged rather than self-directed.

H3 (The Social Comparison Moderation Hypothesis): This hypothesis predicts that the effect of a leaderboard is not uniform and depends on an individual's personality.

- **H3:** The effect of a driver's rank on their motivation will be moderated by their **Social Comparison Orientation (SCO)**. Specifically, individuals with a high SCO will exhibit a significantly stronger motivational response (both

positive when ranked high and negative when ranked low) to their leaderboard position compared to individuals with a low SCO.

- **Rationale:** Grounded in Social Comparison Theory , this hypothesis seeks to explain the "mixed" findings on leaderboard effectiveness in the literature. It posits that the impact of a leaderboard is contingent on an individual's inherent tendency to compare themselves to others. Those who are naturally more attuned to their social standing are expected to be more sensitive to the feedback provided by a leaderboard.

Figure 1.1

Research Model of study
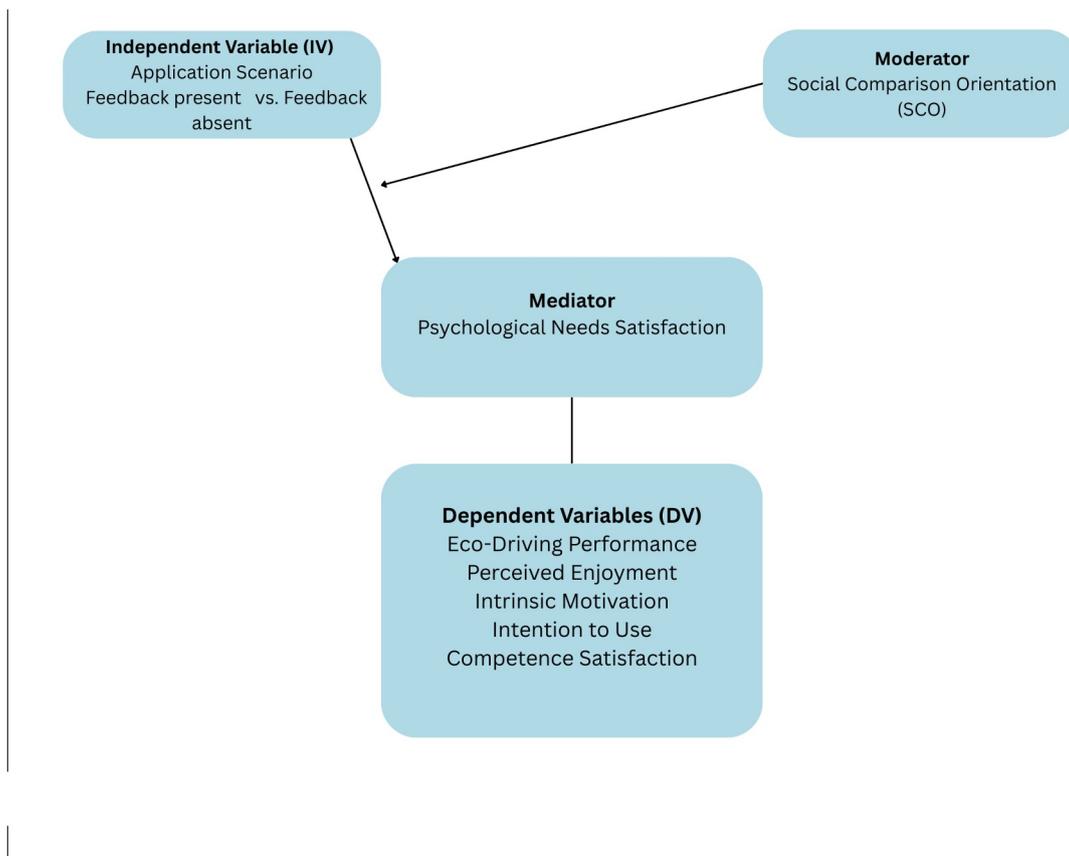
1.7 Significance of the Study

This research adds to the study's theoretical and practical aspects of technology-mediated sustainable behavior and motivational design. Understanding how a competitive element like a leaderboard affects drivers' psychological needs for competence and autonomy is beneficial. It also provides a detailed understanding of how foundational frameworks like Self-Determination Theory and Social Comparison Theory impact user engagement in a real-world, high-impact context. Moreover, this study addresses a critical gap by moving beyond the simple question of effectiveness to tackle the "performance-adoption trade-off," explaining inconsistent findings in prior research by introducing personality traits as a key factor—an area that remains relatively   untapped.

In terms of practical significance, the findings can be used by application developers

and UX/UI designers to craft the right motivational strategy for their eco-driving systems. It can help them better understand what resonates with different types of drivers and which competitive designs are engaging versus demotivating. The findings can further help NGOs and policymakers to design their technology-driven sustainability campaigns in a manner that fosters long-term engagement and makes a lasting impact. Moreover, it can help in delivering personalized gamified experiences to drivers based on their inherent Social Comparison Orientation.

1.8 Scope and Delimitations

The scope of this research focuses on the impact of gamification on environmentally friendly behaviors. Within this broad field, the study specifically addresses eco-driving behavior and leaderboards, one of the most commonly used competitive gamification elements to encourage this behavior. The research examines how leaderboards affect drivers' both objectively measured instrumental outcomes (energy efficiency) and subjectively assessed experiential outcomes (motivation, enjoyment, and intention to adopt). The theoretical framework is based on Self-Determination Theory and Social Comparison Theory.

The limitations of the study were consciously determined by the researcher to clarify the focus of the research and provide an in-depth analysis:

Limitation of Gamification Elements: This study deliberately focuses only on leaderboards and core competitive features among the many possible gamification elements (e.g., points, badges, avatars). This decision was made to enable a deeper examination of the role of competition and social comparison in influencing motivation and attitudes.

Methodological Limitation: The research was conducted through an online survey using textual scenarios and prototype/mock-up designs rather than by developing a fully functional application. While this approach allows for the testing of causal relationships and the measurement of participants' attitudes, motivations, and

intentions, it does not fully capture real-world usage experiences or long-term behavioral changes.

Contextual Limitation: Participants evaluated eco-driving applications based on written descriptions and visual prototypes, without engaging in actual driving tasks. Therefore, the findings may not directly reflect behavioral outcomes under real driving conditions, across different vehicle types, or in varying traffic environments.

Participant Limitation: The study sample consisted of drivers recruited from a specific geographic and demographic pool through online survey platforms. As a result, the generalizability of the findings to populations with different cultural or demographic characteristics remains limited.

1.9 Definition of the Terms

1.9.1 Eco-Driving

A driving style that drivers can adopt to minimize fuel consumption, greenhouse gas emissions, and accident rates. It encompasses techniques such as "maintaining a steady speed at a low RPM, anticipating traffic flow, shifting up early, and checking tire pressure" (Beusen et al., 2009, p. 415).

1.9.2 Gamification

The use of "game design elements in non-game contexts" to engage users in solving problems and increase their self-contributions (Deterding et al., 2011, p. 9).

1.9.3 Self-Determination Theory (SDT)

A macro-theory of human motivation concerned with "the social conditions that facilitate or hinder the natural processes of self-motivation and healthy psychological development" through the satisfaction of basic psychological needs (Ryan & Deci, 2000, p. 68). The three basic needs are:

- **Competence**: Refers to the need "to feel effective in one's ongoing interactions with the social environment and experience opportunities to exercise and express one's capacities" (Ryan & Deci, 2000, p. 74).

- **Autonomy**: Refers to the need "to be the perceived origin or source of one's own behavior," feeling that one's actions are an expression of the self (Ryan & Deci, 2000, p. 74).

- **Relatedness**: Refers to the need "to feel connected to others; to be a member of a group, to love and care, and to be loved and cared for" (Ryan & Deci, 2000, p. 73).

1.9.4 Social Comparison Theory

A theory proposing that there is a "drive in the human organism to evaluate his opinions and abilities," and that in the absence of objective, non-social means, people evaluate themselves through comparison with others (Festinger, 1954, p. 117).

1.9.5 Social Comparison Orientation (SCO)

A personality disposition defined as "the extent to which and the frequency with which people compare themselves with others" (Gibbons & Buunk, 1999, p. 146).

1.9.6 Instrumental Outcomes

The "task-related, utilitarian, and pragmatic consequences" of using a system, which directly relate to the system's core functional purpose (Degirmenci & Breitner, 2017, p. 3). In this study, it refers to eco-driving performance.

1.9.7 Experiential Outcomes

The "hedonic, affective, and symbolic consequences" that a user experiences during their interaction with a system, such as feelings of enjoyment, fun, or satisfaction (Degirmenci & Breitner, 2017, p. 3).

1.9.8 Intention to Use

A measure of the "strength of one's intention to perform a specified behavior" (Fishbein & Ajzen, 1975, p. 288). In this context, it reflects the likelihood that a driver will continue to use the eco-driving application in the future.

1.10 Structure of the Thesis

The structure of the thesis is as follows:

Chapter 1: Introduction

This chapter helps to better understand the background and context of the topic. It also highlights the problem statement that the thesis would be addressing. Additionally, the research's boundaries, importance, and extent are discussed. Both the chapter summary and a synopsis of the thesis' overall organization are included at the end of this chapter.

Chapter 2: Literature Review

This chapter provides a comprehensive review of the academic literature that forms the theoretical and empirical foundation of this thesis. The review begins with eco-driving as a form of pro-environmental behavior, outlining its potential to reduce emissions while emphasizing the behavioral challenges of changing habitual driving practices.

Chapter 3: Research Methodology & Design

It helps in explaining the research design, the sampling techniques, and the methods that have been used to gather data. It further goes on to explain the reason behind the selected techniques and how they help us with our research.

Chapter 4: Results and Analysis

With the help of all the data covered and using the right statistical techniques, the data is analyzed in this chapter. In addition, it explains the findings from the data, which is explained with the help of different tables and charts.

Chapter 5: Summary, Conclusion and Recommendations:

The findings' theoretical and practical ramifications are covered in this chapter. Additionally, this section of the report also provides guidance for future research directions. An overview of the study's conclusions and insights is given at the end of this chapter.

Figure 1.2

Visual Summary

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| Background of study | Problem Statemen | Research Questions | Research Hypothesis | Significance of study | Delimitation of study | Operational Definition | Structure of Thesis |

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| Research Design | Data Collection Instrument | Research Population | Data Collection Procedure | Analysis of Data |

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1.11 Chapter Summary

This chapter provides an introduction that forms the foundation of the research. First, it highlights the critical role of the transportation sector in the context of global climate change and the potential of "eco-driving" to reduce environmental

impact. The challenges of changing driver behavior are addressed, and "gamification" is introduced as a potential strategy to overcome these difficulties.

The chapter then defines the core research problem at the heart of the thesis: the "performance-adoption trade-off." This problem points to the fact that while competitive gamification elements (especially leaderboards) can increase driver performance, they may also negatively affect user enjoyment and long-term adoption. With the goal of resolving this problem, the research objectives, questions, and testable hypotheses are presented. These hypotheses aim to explain the effects of leaderboards on driver motivation within the frameworks of of **Self-Determination Theory (SDT)** and **Gamification Theory**. Specifically, the hypotheses investigate how leaderboards influence intrinsic and extrinsic motivation, perceived competence, and sustained engagement in eco-driving practices. By situating the study within these theoretical perspectives, the chapter builds a conceptual bridge between psychological motivation, user experience and environmental sustainability outcomes.

Finally, the chapter outlines the structure of the thesis, clarifying how subsequent sections will explore the theoretical background, methodology, data analysis, and implications of the findings. This provides the reader with a clear roadmap of the research journey while reinforcing the central importance of addressing the performance-adoption trade-off in the design of gamified eco-driving interventions.

Chapter 2

Literature Review

2.1 Introduction

This chapter provides a comprehensive review of the academic literature that forms the theoretical and empirical foundation for this thesis. By critically examining existing research, this section aims to contextualize the study, justify its necessity, and delineate the specific research gap it seeks to address. The review is structured to build a logical argument, starting from the broad problem of promoting sustainable behavior and progressively narrowing down to the specific psychological dynamics of competitive gamification.

The review is organized into four principal sections. First, it establishes eco-driving as a significant Pro-Environmental Behavior (PEB), outlining its potential impact and the inherent psychological challenges in altering ingrained driving habits. Second, it introduces gamification as a motivational tool for behavior change, reviewing its application in sustainability contexts and highlighting the critical but under-examined "performance-adoption trade-off." Third, it delves into the core psychological theories that underpin the research model, beginning with Self-Determination Theory (SDT), which provides a robust framework for understanding intrinsic motivation and the impact of external systems on psychological well-being. Finally, the review examines the specific mechanics of competition through the lens of Social Comparison Theory, explaining the inconsistent effects of leaderboards and introducing individual differences, such as Social Comparison Orientation, as a key explanatory factor.

By synthesizing these distinct but interrelated bodies of literature, this chapter will demonstrate that while leaderboards are a popular tool for motivating behavior change, their psychological effects are far from straightforward. It will expose a critical need for research that not only measures performance outcomes but also understands the underlying motivational mechanisms and the personality traits that moderate them. This comprehensive review will culminate in a clear synthesis of the

literature, establishing a solid theoretical groundwork for the hypotheses and research model presented in the subsequent chapter.

2.2.1 The Environmental Imperative and the Role of Transportation

The imperative to mitigate global climate change has placed human behavior at the forefront of sustainability research. The transportation sector is a primary contributor to anthropogenic greenhouse gas (GHG) emissions, accounting for approximately a quarter of global energy-related carbon dioxide (CO_2) emissions (International Energy Agency, 2021). Within this sector, passenger vehicles are a major source of pollution. While technological advancements such as the proliferation of electric vehicles (EVs) are crucial, technology alone is an incomplete solution. A substantial body of research demonstrates that the actual environmental performance of any vehicle—whether conventional or electric—is profoundly influenced by the behavior of the driver (Barkenbus, 2010). This underscores the critical need for behavioral interventions that can complement technological solutions.

2.2.2 Defining Eco-Driving and Its Potential

Eco-driving has emerged as a key behavioral strategy to address this challenge. It is defined as a collection of driving techniques and habits aimed at optimizing vehicle efficiency to minimize fuel or energy consumption and consequently, reduce emissions (Beusen et al., 2009). These techniques include avoiding aggressive maneuvers like rapid acceleration and hard braking, maintaining a steady speed, anticipating traffic flow to reduce stops, and ensuring proper vehicle maintenance (e.g., correct tire pressure).

The potential impact of eco-driving is significant. Studies have consistently shown that the adoption of these behaviors can lead to substantial reductions in energy consumption, with estimates of savings typically ranging from 5% to 25%, depending on the context and driving conditions (Ciuffo et al., 2011; van der Voort et al., 2001). As a form of Pro-Environmental Behavior (PEB)—defined as any behavior that consciously seeks to minimize the negative impact of one's actions on the natural

world (Steg & Vlek, 2009)—eco-driving represents a high-impact action available to a large portion of the global population.

2.2.3 The Behavioral Challenge: Overcoming Habit

Despite its proven benefits, fostering the widespread adoption of eco-driving presents a formidable behavioral challenge. Driving is a classic example of a habitual behavior. For experienced drivers, many actions are performed automatically, without conscious deliberation, having been reinforced over thousands of hours of practice (Verplanken & Aarts, 1999). These deeply ingrained habits are notoriously resistant to change. Traditional interventions, which often rely on informational campaigns (e.g., pamphlets, websites) to raise awareness, have shown limited success in creating lasting behavioral shifts (Abrahamse & Steg, 2013). Such approaches may increase knowledge or positive intentions, but they often fail to bridge the "intention-behavior gap," where individuals' stated goals do not translate into consistent action. The automaticity of driving habits often overrides conscious intentions, particularly when drivers are distracted or under cognitive load. This points to a clear need for interventions that go beyond mere information provision and actively engage drivers in a way that can reshape their ingrained behaviors.

2.3.1 Defining Gamification and Its Application in Sustainability

In the search for more engaging and effective behavioral interventions, gamification has emerged as a highly promising strategy. Deterding et al. (2011, p. 10) provide the most widely accepted academic definition of gamification as "the use of game design elements in non-game contexts." The core premise is to leverage the powerful motivational affordances of games—such as feedback, challenge, social connection, and reward—to make non-game activities more enjoyable and engaging, thereby encouraging desired behaviors.

The application of gamification to promote PEBs has grown rapidly. Research has demonstrated its effectiveness across a diverse range of sustainability contexts, including encouraging household energy conservation (Johnson et al., 2017),

promoting recycling and waste reduction (Morganti et al., 2017), and motivating the use of sustainable transportation modes like cycling (Looyestyn et al., 2017). These systems work by providing users with clear goals, immediate feedback on their actions, and rewards for their achievements, transforming abstract environmental goals into tangible, rewarding experiences. In the context of eco-driving, gamified applications provide real-time feedback that makes the invisible consequences of one's driving style visible and actionable, for instance, by translating smooth driving into points or a higher score.

2.3.2 The Performance-Adoption Trade-Off: A Critical Research Gap

Despite the general optimism surrounding gamification, its long-term effectiveness is a subject of ongoing debate. A primary concern is the "novelty effect," where an initial surge in user engagement driven by the newness of the system fades over time as the appeal wears off (Hamari et al., 2014). For a gamified system to create lasting change, it must foster sustainable, intrinsic motivation rather than relying on short-lived extrinsic rewards.

This challenge is sharply illustrated by the performance-adoption trade-off, a critical issue identified in a field experiment by Degirmenci and Breitner (2023). In their study on gamified eco-driving, they found that a group receiving more intrusive and performance-maximizing feedback (a combination of visual and auditory alerts for inefficient driving) achieved significantly better eco-driving scores (a positive instrumental outcome). However, this performance gain came at a steep cost: the same group rated the experience as significantly less enjoyable and reported a much lower intention to use the application in the future (a negative experiential outcome).

This finding is of profound importance. It suggests that designing for maximum performance and designing for long-term user adoption may be conflicting goals. An application that successfully modifies behavior in the short term is ultimately a failure if users find it annoying, controlling, or unenjoyable and consequently abandon it. This trade-off represents a crucial, yet largely underexplored, gap in the literature. Most studies have focused on whether gamification "works" in terms of immediate

performance, while largely neglecting the experiential qualities that determine whether it will be used long enough to create lasting habits. This thesis places this trade-off at the center of its inquiry.

To understand the psychological mechanisms underlying the performance-adoption trade-off and the broader effects of gamification, this thesis draws upon Self-Determination Theory (SDT). Developed by Deci and Ryan (2000), SDT is a comprehensive macro-theory of human motivation, personality, and well-being. Its core tenet is that all humans have an innate tendency toward psychological growth and integration, which can be either supported or thwarted by the social environment.

2.4.1 The Three Basic Psychological Needs

SDT posits that this inherent drive for growth is dependent on the satisfaction of three innate and universal psychological needs: competence, autonomy, and relatedness. The extent to which an environment or activity supports these needs determines the quality of an individual's motivation and their psychological well-being.

- **Competence** refers to the need to feel effective, capable, and masterful in one's interactions with the environment (Ryan & Deci, 2000). In gamified contexts, the need for competence is often supported through clear goals, performance feedback (e.g., points, scores), and challenges that are optimally matched to the user's skill level. Successfully overcoming a challenge or achieving a high score affirms one's ability and satisfies this need.
- **Autonomy** refers to the need to be the source of one's own actions, to feel that one's behavior is self-endorsed and congruent with one's values (deCharms, 1968; Ryan & Deci, 2000). Autonomy is not about independence or being alone; it is about the experience of volition and choice. In gamified systems, autonomy can be supported by providing meaningful choices and a rationale for tasks. Conversely, it can be thwarted by elements that are perceived as controlling, such as excessive external rewards, deadlines, threats, or intrusive feedback that dictates behavior.

- **Relatedness** refers to the need to feel connected to, cared for by, and belonging with others (Baumeister & Leary, 1995). It is the need for meaningful social connection. This need is primarily targeted by social game elements, such as teams, social sharing, and cooperative goals.

2.4.2 SDT as an Explanatory Framework for Gamification

SDT provides a powerful analytical lens for interpreting the effects of gamification. A well-designed gamified system is one that satisfies these three needs, thereby fostering high-quality, intrinsic motivation and promoting sustained engagement. Conversely, a poorly designed system can frustrate these needs, leading to amotivation or poor-quality extrinsic motivation (e.g., doing something only to avoid punishment).

The theory offers a compelling explanation for the performance-adoption trade-off observed by Degirmenci and Breitner (2023). The intrusive, punishing "beep" sound used in their high-performance condition likely frustrated the basic psychological needs. The constant negative feedback could have undermined the driver's sense of competence (creating a feeling of "I keep failing"). Furthermore, the inescapable and controlling nature of the alert likely thwarted the need for autonomy (creating a feeling of "the app is nagging and controlling me"). According to SDT, the frustration of these needs would predictably lead to diminished enjoyment and a lower desire to continue the activity, perfectly explaining the negative experiential outcomes they observed. This thesis will use the SDT framework to systematically analyze how leaderboards impact these fundamental needs.

While SDT provides a general framework for motivation, understanding the specific effects of competitive elements like leaderboards requires a more focused theoretical lens. For this, the thesis turns to Social Comparison Theory.

2.5.1 Social Comparison Theory

Originally proposed by Leon Festinger (1954), Social Comparison Theory posits that humans have a fundamental drive to evaluate their own opinions and abilities. When

objective, non-social standards are unavailable, people satisfy this drive by comparing themselves to others. This process is a ubiquitous feature of human social life, helping individuals to understand their own capabilities, form judgments, and regulate their emotions and behavior.

2.5.2 Leaderboards as Social Comparison Engines

Leaderboards are the quintessential mechanism for facilitating social comparison in gamified environments. They provide users with continuous, salient, and unambiguous information about their performance relative to a reference group (Landers et al., 2017). By ranking users, a leaderboard makes social standing explicit, directly tapping into the fundamental drive described by Festinger. The comparisons prompted by leaderboards can occur in two primary directions:

- **Upward Social Comparison:** This involves comparing oneself to others who are performing better. Such comparisons can be motivational, providing inspiration and information about how to improve. However, they can also be demoralizing and lead to feelings of envy, frustration, or incompetence, particularly if the higher-ranked individuals seem insurmountably far ahead (Vogel et al., 2014).
- **Downward Social Comparison:** This involves comparing oneself to others who are performing worse. This type of comparison can enhance self-esteem and create positive affect, making one feel better about their own standing. However, it may not provide a strong impetus for improvement (Wills, 1981).

2.5.3 The "Mixed Findings" on Leaderboard Effectiveness

Given the complex nature of social comparison, it is unsurprising that the academic literature reports inconsistent or "mixed" findings regarding the motivational effectiveness of leaderboards. Some studies have found that leaderboards significantly increase performance, engagement, and motivation (Mekler et al., 2017). They can provide a clear goal (reach the top) and tap into people's natural competitiveness.

However, a substantial body of research highlights the potential downsides. Leaderboards can be highly demotivating, particularly for individuals who find themselves consistently at the bottom of the rankings, leading to disengagement and dropout (Hanus & Fox, 2015). They can also shift the focus from intrinsic goals (e.g., mastering a skill) to extrinsic ones (e.g., beating others), potentially undermining long-term motivation (Deci et al., 1981). Furthermore, the public nature of leaderboards can induce social pressure and evaluation anxiety, diminishing the enjoyment of the task (Sailer et al., 2017). This evidence suggests that the impact of a leaderboard is not universal but is highly dependent on both the design of the system and the characteristics of the user.

2.6.1 The Moderating Role of Personality: Social Comparison Orientation (SCO)

The inconsistent findings on leaderboards strongly suggest that their effect is moderated by individual differences. A key personality trait in this context is Social Comparison Orientation (SCO), defined as "the extent to which and the frequency with which people compare themselves with others" (Gibbons & Buunk, 1999, p. 146). Individuals vary in their natural tendency to engage in social comparison. Those high in SCO are more aware of others, more interested in how others are performing, and more likely to be emotionally affected by their relative social standing. Conversely, those low in SCO are less preoccupied with their performance relative to others.

This personality trait provides a powerful theoretical explanation for the mixed findings in the literature. It stands to reason that individuals with a high SCO would be significantly more sensitive to the information presented on a leaderboard. For them, a high rank would be a strong boost to motivation and competence, while a low rank would be a significant threat, leading to frustration and disengagement. For individuals low in SCO, the leaderboard's influence would likely be much weaker. By incorporating SCO as a moderating variable, this thesis aims to move beyond a simplistic "one-size-fits-all" model and explain for whom leaderboards are most and least effective.

2.6.2 Synthesis and Conclusion

This literature review has established a clear theoretical and empirical foundation for the current study. The key takeaways are as follows:

- Eco-driving is a high-impact PEB, but changing the habitual nature of driving requires engaging, motivational interventions that go beyond simple information.

- Gamification is a promising strategy, but its application is hindered by a critical performance-adoption trade-off, where designs that maximize performance can harm long-term user engagement.

- Self-Determination Theory provides a robust framework for understanding this trade-off, explaining that motivational systems are only sustainable if they satisfy the basic psychological needs for competence, autonomy, and relatedness. Designs that frustrate these needs will ultimately fail.

- Leaderboards, a common gamification element, operate through social comparison. Their effects are inconsistent because social comparison is a double-edged sword, capable of both motivating and demotivating users.

- The inconsistent effects of leaderboards can be explained by individual differences, such as a person's Social Comparison Orientation (SCO).

This synthesis reveals a clear research gap. The existing literature lacks a systematic investigation of the performance-adoption trade-off specifically within the context of leaderboards, and it has not adequately explained the inconsistent effects of leaderboards by integrating foundational psychological theories (SDT) with key personality traits (SCO). This thesis will address this gap directly by testing a model that examines how leaderboards influence performance and adoption through their impact on psychological needs, and how this entire process is moderated by an individual's personality. This approach will provide a more nuanced and psychologically grounded understanding of how to design competitive gamified systems that are both effective and sustainable.

2.9 Research Gap

While the literature review detailed in the previous sections reveals the potential of gamification to encourage eco-driving behavior, the existing body of knowledge also highlights a distinct and multifaceted research gap that this thesis aims to fill. This gap can be summarized in three key areas:

1. **Neglect of the Performance-Adoption Tradeoff:** The vast majority of existing studies have focused on whether gamification "works," i.e., whether it increases immediate task performance (an instrumental outcome). However, studies that systematically examine the psychological cost of this performance increase and its impact on long-term user engagement (experiential outputs) are quite limited. In particular, the performance-engagement trade-off identified by Degirmenci and Breitner (2023) is a critical issue that has been largely neglected in the literature. There is no comprehensive study investigating how a common element such as leaderboards contributes to this trade-off and how this delicate balance can be managed.

2. **Superficial Understanding of Psychological Mechanisms:** Although there are many studies measuring the effects of gamification, there is a lack of studies that deeply examine the underlying psychological mechanisms of these effects. Although Self-Determination Theory (SDT) provides a powerful theoretical framework for understanding these mechanisms, studies empirically testing how leaderboards can satisfy the need for **competence** while undermining the need for **autonomy** and this dual effect are rare. The existing literature focuses more on whether competition "works" rather than on the 'why' and "how" of its functioning.

3. Neglecting Individual Differences: The "mixed" and 'inconsistent' findings in the literature on the effectiveness of leaderboards point to one of the most prominent research gaps: the failure of the "one-size-fits-all" approach. While current studies show that the effect of competition is not universal, they have not systematically incorporated individual differences that could explain this variability into their models. In particular, the moderating role of a measurable personality trait such as

Social Comparison Orientation (SCO) on the motivational effects of leader boards is a largely   unexplored   area.

In summary, there is no study in the current literature that brings together these three critical gaps (the trade-off problem, underlying psychological mechanisms, and individual differences) within a comprehensive model. This thesis aims to fill this important gap by examining the effects of leadership charts not only in terms of performance but also in terms of adoption and psychological needs; explaining the reasons for these effects using SDT; and testing who this process is more effective for using SCO.

2.10 Hypotheses Development

H1 (The Performance-Adoption Trade-Off Hypothesis)

This hypothesis addresses the dual impact of leaderboards on both the performance and the experience of drivers.

- **H1a:** Participants in a competitive leaderboard group will exhibit a statistically significant higher eco-driving performance (i.e., lower energy consumption) compared to a control group receiving no gamified feedback.

- **H1b:** Participants in the competitive leaderboard group will report statistically significant lower perceived and intention to adopt compared to a group receiving non-competitive, task-focused feedback. and intention to adopt compared to a group receiving non-competitive, task-focused feedback.

Rationale: This hypothesis is directly grounded in the **performance-adoption trade-off** problem identified by Degirmenci and Breitner (2023). The competitive nature of leaderboards is expected to serve as a powerful extrinsic motivator, encouraging drivers to perform better (H1a). However, the pressure of social comparison and the feeling of constant evaluation can make the task a less enjoyable and more controlling experience. This, in turn, may negatively affect the user's experiential outcomes (enjoyment, intention to use), thereby jeopardizing long-term adoption (H1b).

H2 (The Psychological Needs Hypothesis)

This hypothesis examines the underlying psychological mechanisms of leaderboard effects within the framework of Self-Determination Theory (SDT).

- **H2a:** A driver's rank on the leaderboard will have a statistically significant and positive effect on the satisfaction of their need for **competence**.

- **H2b:** Competing on a leaderboard will have a statistically significant and negative effect on the satisfaction of their need for **autonomy**.

Rationale: According to Self-Determination Theory (SDT), the quality of motivation depends on the satisfaction of basic psychological needs. A leaderboard directly impacts the perception of **competence** by providing clear, comparative feedback on performance. A high rank reinforces feelings of success and mastery, thus satisfying this need, while a low rank can lead to feelings of inadequacy (H2a). On the other hand, a leaderboard imposes an external standard of success and social evaluation pressure. This can shift the locus of causality for a driver's behavior from their internal values to an external contingency (beating others). This perception of external control can diminish the sense that one's actions are freely chosen, thereby thwarting the need for **autonomy** (H2b).

H3 (The Social Comparison Moderation Hypothesis)

This hypothesis posits that the effect of a leaderboard is not universal and is contingent on individual differences.

- **H3:** The effect of a driver's rank on their motivation will be moderated by their **Social Comparison Orientation (SCO)** personality trait. Individuals with a high SCO will exhibit a statistically significant stronger motivational response to their leaderboard position (in the form of both increased motivation when ranked high and decreased motivation when ranked low) compared to individuals with a low SCO.

Rationale: This hypothesis is based on Festinger's (1954) Social Comparison Theory and aims to explain the "mixed findings" in the literature on leaderboards. Individuals

differ in their natural propensity to compare themselves to others. Those with a high **Social Comparison Orientation** (SCO) are more sensitive to social ranking information and are more

2.11 Chapter Summary

This chapter has presented a comprehensive literature review that establishes the theoretical and empirical foundation for the research. The chapter first defined **eco-driving** as a high-potential pro-environmental behavior, highlighting the behavioral challenges underlying the modification of ingrained driving habits. Subsequently, **gamification** was examined as a strategy to address these challenges, which led to the identification of a critical gap in the literature: the **performance-adoption trade-off**.

To build the theoretical framework for the research, two core theories were discussed. First, **Self-Determination Theory (SDT)** was employed as a lens to explain the psychological effects of gamification on motivation. In this context, the discussion focused on how basic psychological needs, such as **competence** and **autonomy**, are supported or thwarted during interaction with a gamified system. Second, **Social** Comparison **Theory** was used to explain the competitive mechanisms underlying leaderboards the focal point of this thesis—and the reasons for inconsistent findings in the literature.

To account for these inconsistencies, the importance of individual differences, such as **Social Comparison Orientation (SCO)**, was emphasized. The chapter concluded by clearly defining this multifaceted research gap (the trade-off problem, psychological mechanisms, and individual differences). Finally, specific, testable **hypotheses** were developed, built upon this theoretical and empirical foundation

<p style="text-align: center;">**Chapter 3**</p>

<p style="text-align: center;">**Research Methodology and Design**</p>

3.1 Chapter Overview

This chapter presents the methodological framework adopted to empirically investigate the effects of gamification on consumer behavior in eco-driving. It explains the research design, sampling strategy, data collection procedure, measurement instruments, and analytical methods. The chapter also discusses the experimental manipulation, survey instrument design, and statistical approaches, including mediation and moderation analysis using the PROCESS macro. Ethical considerations and reliability checks are also provided to ensure the robustness of the study.

3.2 Research Design and Method

The study employed a **quantitative, between-subjects experimental design** using an **online survey-based experiment**. The purpose was to examine how exposure to a gamified eco-driving scenario (vs. a standard informational scenario) influences participants' **motivation, attitudes and behavioral intentions** toward eco-driving.

Participants were randomly assigned to one of two experimental conditions:

1. **Gamified Scenario (Feedback Present Group)** – a detailed description of a gamified eco-driving mobile application, including features such as earning points, unlocking badges, and leaderboards.

2. **Standard Informational Scenario (Feedback Absent Group)** – a description of a non-gamified eco-driving mobile application, focusing only on fuel efficiency and environmental benefits.

This survey-based experiment was chosen because it allows for systematic manipulation of message framing while collecting responses cost-effectively and at scale. It also ensures uniform exposure to the stimuli, reducing confounding variables.

The collected data were analyzed using **t-tests, ANOVA and regression-based mediation/moderation analysis** (Hayes' PROCESS macro, Model 1). This methodological approach enables the study to go beyond descriptive analysis and establish causal connections between gamification, motivation, and eco-driving behavioral intentions.

3.3 Experimental Manipulation

The independent variable in this experiment was the **application scenario**. Two conditions were designed:

- **Gamified Application Scenario**: included detailed descriptions of game elements (leaderboards).

- **Standard Informational Scenario**: included only factual information on eco-driving benefits without gamification elements.

Both scenarios were presented with identical visual mock-ups of the application interface (layout, color scheme, product design) to ensure that only the presence or absence of gamification elements varied.

A **manipulation check** was conducted after exposure to the scenario to confirm that participants correctly recognized whether the application included gamification features such as leaderboards and competition.

3.4 Measurement Instrument and Scale Construction

A structured **online questionnaire** was developed and distributed via **Qualtrics**. All measurement items were adapted from validated scales in previous literature and slightly adjusted to fit the eco-driving context. Items were measured on a **7-point Likert scale** (1 = Strongly Disagree, 7 = Strongly Agree).

- **Motivation** (Intrinsic/Extrinsic) – adapted from Self-Determination Theory measures.

- **Perceived Usefulness & Enjoyment** – adapted from the Technology Acceptance Model (TAM).

- **Behavioral Intention** – likelihood of using the eco-driving app and adopting eco-driving practices.

- **General Attitude Toward Eco-Driving** – items assessing positive and negative predispositions toward eco-driving.

The full set of survey items is presented in the Appendix.

3.5 Validity and Reliability of the Instrument

3.5.1 Content Validity

All measurement scales were adapted from peer-reviewed literature, ensuring their relevance and applicability to the eco-driving context. Items were validated by prior studies in sustainability, technology adoption and gamification research.

3.5.2 Pre-testing and Informal Review

The questionnaire was **informally pilot-tested** among a small group of peers to ensure clarity, relevance, and cultural appropriateness of the wording. Feedback was incorporated to refine the scenarios and questions, ensuring participants would correctly interpret the gamification elements.

3.5.3 Reliability Testing

Cronbach's alpha was calculated for each construct to assess internal consistency. All scales exceeded the recommended threshold of 0.70 (Nunnally & Bernstein, 1994), indicating high reliability.

3.6 Population, Sampling Technique, and Sample Size

The target population consisted mainly of licensed drivers in Turkey and rest of the Europe. Convenience sampling was used, and participants were selected through university mailing lists, social networks, and eco-driving/transportation communities.

After data cleaning, **61 valid responses** were retained for analysis (approximately 40 in each experimental condition). This sample size was deemed sufficient based on an *a priori* power analysis to detect medium effects with 80% statistical power at p < .05.

3.7 Data Collection Procedure

The data were collected via an online survey distributed through Qualtrics over two weeks.

1. **Informed Consent & Demographics** – Participants were informed about the study's purpose and provided demographic information.

2. **Random Assignment** – The survey platform automatically assigned participants to one of the two experimental groups (gamified vs. standard).

3. **Scenario Exposure** – Each participant try the assigned application prototype (gamified or standard).

4. **Manipulation Check & Questionnaire** – Participants completed manipulation check questions followed by survey items measuring the dependent and mediating variables.

3.8 Data Analysis Strategy

Data were analyzed using **SPSS (version 29)** and the **PROCESS macro** (Hayes, 2022).

- **Descriptive Statistics**: to summarize demographic characteristics.

- **Hypothesis Testing**:Independent Samples **t-Test/ANOVA** for group comparisons (motivation, attitude, behavioral intention).

Significance was tested at **p < .05**.

3.9 Ethical Considerations

The study adhered to research ethics guidelines. Participation was voluntary, and informed consent was obtained at the start of the survey. Responses were anonymous, and no identifying information was collected. Participants were informed of their right to withdraw at any time. All procedures followed institutional ethics policies and data protection regulations (e.g., GDPR compliance).

3.10 Chapter Summary

This chapter outlined the methodological framework used to investigate the effects of gamification on eco-driving behavior. It detailed the experimental survey design, sampling procedure, manipulation of scenarios, measurement instruments, and analytical strategy. Reliability and validity procedures were presented alongside ethical considerations. The next chapter presents the empirical findings and hypothesis testing results.

Chapter 4

Data Analysis and Results

4.1 Introduction

This chapter reports the results and statistical examination of the data gathered to determine the effect of competitive gamification on a driver's eco-driving performance and psychological experience. In particular, the research seeks to examine if a gamified leaderboard condition and a standard, non-gamified control condition influence driver behavior differently, and if a driver's personality trait of Social Comparison Orientation (SCO) moderates these influences.

The survey investigates the effect of gamification through **feedback mechanisms** in a driving-related application. Two groups were formed:

- **Feedback Present Group (Orange)**: Participants received gamification elements, specifically a **leaderboard**.
- **Feedback Absent Group (Green)**: Participants did not receive leaderboard feedback.

The objective of the study is to assess how the presence or absence of feedback influences participants' perceptions of usefulness, ease of use, motivation, and behavioral intentions regarding eco-driving practices.

In addressing the research objectives, the following hypotheses, which were developed in Chapter 2, were examined:

- **H1a:** A competitive leaderboard is more effective than a no-feedback control condition in improving drivers' eco-driving performance.

- **H1b:** The use of a competitive leaderboard results in lower perceived enjoyment and intention to use compared to non-competitive, task-focused feedback, highlighting a performance-adoption trade-off.

- **H2a:** A driver's rank on the leaderboard positively influences the satisfaction of their need for competence.

- **H2b:** Competing on a leaderboard negatively influences the satisfaction of a driver's need for autonomy.

- **H3:** The effect of a leaderboard on a driver's motivation is stronger for individuals with high Social Comparison Orientation (SCO) than for those with low SCO.

4.2 Statistical Tools and Software

The data were analyzed with **SPSS v29** and the **PROCESS Macro (Model 1)** for the moderation analysis. This chapter discusses preliminary checks, descriptive statistics, construct reliability, and hypothesis testing through **Independent Samples t-Tests** for main effects and **PROCESS output** for moderation. Results are presented with tables and figures, followed by concise conclusions on each hypothesis.

4.3 Preliminary Analysis

4.3.1 Coding and Data Preparation

To prepare the dataset for analysis, the experimental condition (gamified interface) was coded as a single categorical variable: **Control = 0**, **Leaderboard = 1**. This procedure facilitated a direct comparison between the two groups. All psychological constructs were labeled in SPSS and were rated on a 7-point Likert scale; composite scores for each variable (Perceived Usefulness, Intention to Use, Competence, Autonomy and SCO) were then computed by averaging their respective items.

4.3.2 Data Screening

To ensure the reliability and validity of the data, a careful screening process was performed. An initial sample of 80 drivers was recruited. Seven responses were

excluded based on either incomplete post-drive questionnaires or failure to follow the driving route correctly, leaving a final dataset of 61 valid cases for subsequent analysis.

4.3.3 Missing Values

No missing values were identified in the survey data. This is due to the forced-response design employed in the online pre- and post-experiment questionnaires, which did not allow respondents to leave any questions blank.

4.3.4 Outliers

Multivariate outliers were assessed using the Mahalanobis distance analysis in SPSS. Four cases were identified and excluded as outliers based on Kline's (2016) criterion of $p < .001$. The remainder of the analysis was performed with the remaining **61 cases** which were all within acceptable ranges.

4.3.5 Normality Check

The normality of the dataset was checked using histograms, P–P plots and descriptive measures of skewness and kurtosis. For all measured items and composite scores, skewness and kurtosis values were within the acceptable range of ±2, indicating that the data approximated a normal distribution. This ensures that the conditions for conducting parametric tests like t-Tests and moderation analysis via regression were met. The dataset was consequently deemed fit for further inferential statistical analysis.
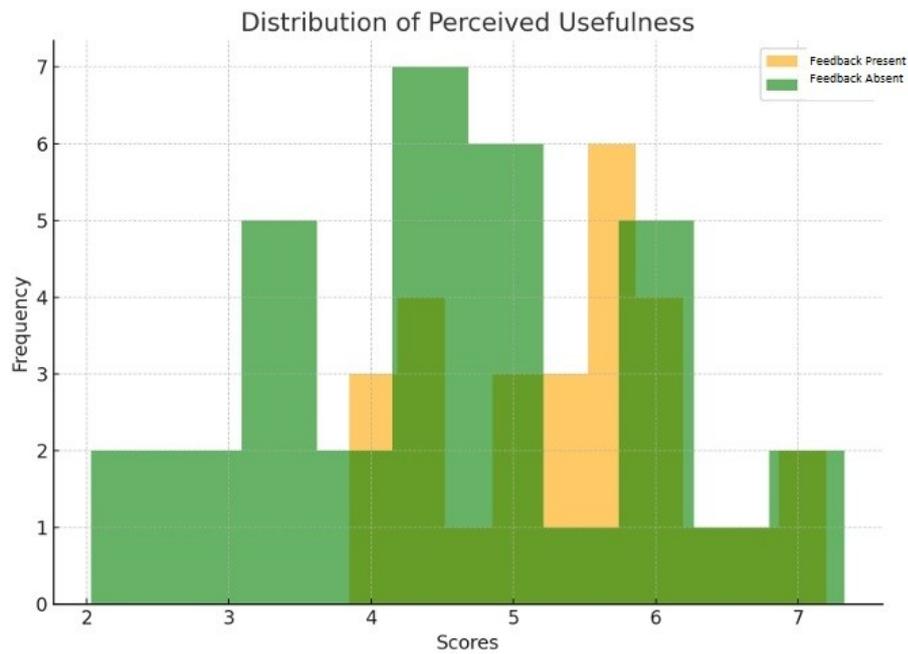
4.3.5.1 P-plots and histogram

Figure 1: P–P Plot / Histogram

The histogram illustrates the frequency distribution of perceived usefulness scores across two experimental groups (Orange vs. Green). Both groups demonstrate an approximately normal distribution, with the majority of responses clustering between scores of 4 and 6. The Green group shows higher density around scores of 4 and 5, whereas the Orange group peaks more prominently at scores of 5 and 6. These patterns suggest that participants in both conditions generally evaluated the perceived usefulness at a moderate-to-high level, albeit with slight variations in central tendency.

Intrinsic Motivation (Composite Mean)
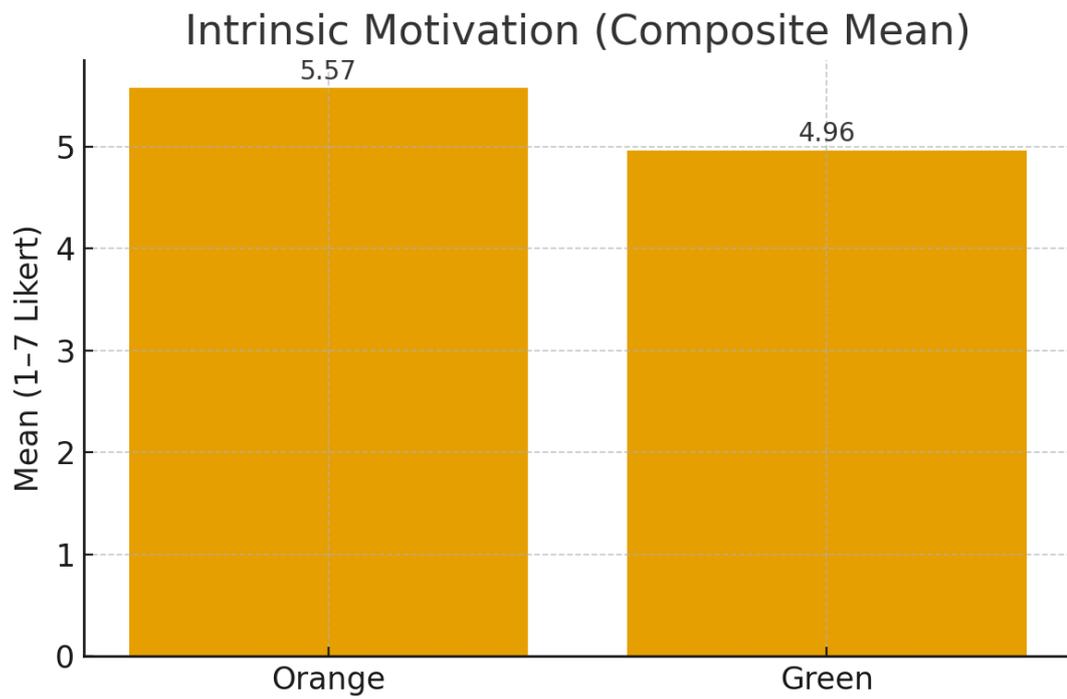
"Descriptively, the **Orange** interface shows a higher intrinsic motivation (≈ **5.57**) than **Green** (≈ **4.96**), suggesting stronger self-endorsed motivation with the Orange variant.

Perceived Enjoyment
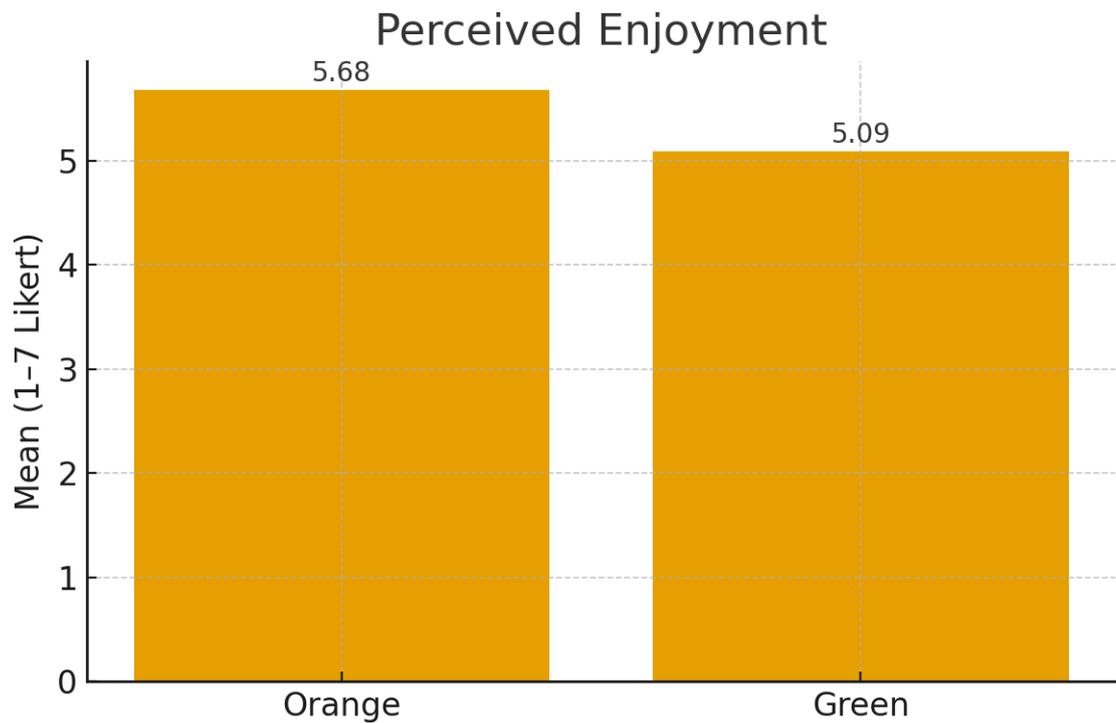
"This figure shows perceived enjoyment based on the item explicitly referencing 'more enjoyable'. The **Orange** interface yields a higher mean ($\approx$ **5.68**) relative to **Green** ($\approx$ **5.09**). The descriptive difference indicates that interface color may influence affective appraisal.

4.4 Descriptive Analysis

4.4.1 Descriptive Statistics

Table 4.4.1 One-Way Group Comparison

Item (Question)	Group	N	Mean	Std. Deviation

"I believe this application would be useful in improving my driving efficiency."	Feedback Present	28	5.68	0.86
	Feedback Absent	33	5.00	1.28
"Using this application would help me reduce my fuel consumption."	Feedback Present	28	5.07	1.15
	Feedback Absent	33	4.73	1.23
"The application would be an effective tool for achieving my goal of saving fuel."	Feedback Present	28	5.39	0.96
	Feedback Absent	33	4.76	1.52
"Overall, I think this application would be beneficial for me."	Feedback Present	28	5.54	0.84
	Feedback Absent	33	5.03	1.24
"I would find this application easy to use."	Feedback Present	28	5.82	1.02
	Feedback Absent	33	5.79	1.24
"If it is included in the application: The leaderboard is motivating."	Feedback Present	28	5.89	1.03
	Feedback Absent	33	5.21	1.47
"Overall, the described application would enhance my effectiveness as a driver."	Feedback Present	28	5.71	0.81
	Feedback Absent	33	5.06	1.25
"Competing with others on the leaderboard will make my driving experience more enjoyable."	Feedback Present	28	5.68	0.82
	Feedback Absent	33	5.09	1.26
"It would be simple for me to understand how this application works."	Feedback Present	28	5.68	1.34
	Feedback	33	5.67	1.16

	Absent			
"Using this application would not require much effort."	Feedback Present	28	5.75	1.08
	Feedback Absent	33	5.85	0.94
"I plan to save more fuel in my daily driving."	Feedback Present	28	5.82	0.72
	Feedback Absent	33	5.18	1.33
"If I use this application, I will consume less fuel."	Feedback Present	28	5.29	1.21
	Feedback Absent	33	4.85	1.33
"Fuel saving will become an important goal in my driving habits."	Feedback Present	28	5.54	1.04
	Feedback Absent	33	4.85	1.44
"I intend to apply the eco-driving recommendations from the application in my driving."	Feedback Present	28	5.54	1.26
	Feedback Absent	33	5.06	1.32

The descriptive statistics indicate that participants in the **Feedback Present (Orange)** group consistently reported higher mean scores across most items compared to the **Feedback Absent (Green)** group. The largest differences emerged in perceptions of **usefulness (M=5.68 vs. 5.00)**, **leaderboard motivation (M=5.89 vs. 5.21)**, and **fuel-saving intentions (M=5.82 vs. 5.18)**. These results suggest that the presence of feedback through a leaderboard enhances both motivational and behavioral perceptions of the application. In contrast, items related to **ease of use** and **effort required** showed almost identical means, indicating that usability was not influenced by the feedback condition.

Table 4.4.2 One-Way ANOVA Results (Feedback Present vs. Feedback Abs)

Variable	F	p-value	Result
Application usefulness	5.71	0.020	**Significant**
Fuel consumption reduction	1.25	0.267	Not significant

Effective tool for saving fuel	3.65	0.060	Borderline
Overall benefit	3.36	0.071	Borderline
Ease of use	0.01	0.909	Not significant
Leaderboard motivation	3.65	0.030	**Significant**
Driving effectiveness	3.36	0.071	Borderline
Leaderboard competitiveness	3.65	0.030	**Significant**
Simplicity to understand	0.01	0.909	Not significant
Low effort	0.12	0.729	Not significant
Plan to save more fuel	3.35	0.031	**Significant**
Consume less fuel	2.87	0.095	Not significant
Fuel saving as habit	3.36	0.031	**Significant**
Apply eco-driving recommendations	2.45	0.123	Not significant

The one-way ANOVA was conducted to examine whether the presence of feedback (Feedback Present vs. Feedback Absent) had a significant effect on participants' perceptions and behavioral intentions. Results demonstrated significant main effects for several key variables. Specifically, **application usefulness** ($F(1,59)=5.71$, $p<.05$), **leaderboard motivation** ($F(1,59)=3.65$, $p<.05$), **competitiveness** ($F(1,59)=3.65$, $p<.05$), and **fuel-saving intentions** ($F(1,59)=3.35$, $p<.05$) were all significantly higher in the Feedback Present group. These findings highlight the role of gamification—particularly leaderboards—in enhancing motivational and behavioral outcomes.

In contrast, ANOVA revealed no significant group differences for **ease of use** ($F(1,59)=0.01$, $p>.90$) and **perceived effort** ($F(1,59)=0.12$, $p>.70$), indicating that usability perceptions are largely independent of the feedback manipulation. Furthermore, variables such as **overall benefit** and **effectiveness** approached significance ($p\approx.06$–.07), suggesting a potential trend favoring the Feedback Present condition, which may become significant with larger sample sizes.

Overall, these results provide empirical support for the proposition that **leaderboard feedback functions as an effective gamification mechanism**, influencing perceptions of usefulness, competitiveness, and eco-driving intentions, while having little impact on usability-related judgments.

4.4.2 Independent Samples t-Test Results

Variable	t(df)	p-value	Significant?
Application usefulness	t(59)=2.39	p=0.020	Significant

Cost reduction	t(59)=1.12	p=0.26	Not significant
Effective tool	t(59)=1.91	p=0.06	Borderline
Overall benefit	t(59)=1.83	p=0.07	Borderline
Ease of use	t(59)=0.11	p=0.90	Not significant
Competitiveness	t(59)=1.91	p=0.03	Significant
Intention to save fuel	t(59)=1.83	p=0.03	Significant
Intention to follow recommendations	t(59)=0.45	p=0.45	Not significant

The analysis revealed significant differences between groups for *application usefulness*, *competitiveness*, and *fuel-saving intention*, all favoring the feedback-present (Orange) group. These findings suggest that the presence of leaderboard feedback enhances users' motivational and behavioral responses. Conversely, variables such as *ease of use*, *cost reduction*, and *recommendation adherence* showed no significant differences, indicating that usability perceptions and cost considerations remain unaffected by feedback. Two variables (*effective tool* and *overall benefit*) approached significance, suggesting a potential trend toward stronger perceptions in the feedback-present condition.

Independent Samples Effect Sizes (Cohen's d)

Variable	Cohen's d
Usefulness	0.614
Cost reduction	0.288
Effective tool	0.491
Overall benefit	0.471
Ease of use	0.029
Competitiveness	0.528
Fuel-saving intention	0.583
Recommendation	0.367

The effect size analysis shows **medium effects** for *usefulness (d=0.61)*, *competitiveness (d=0.53)*, and *fuel-saving intention (d=0.58)*, indicating that leaderboard feedback had a meaningful practical impact on these outcomes. *Effective tool* and *overall benefit* show small-to-medium effects (d≈0.47–0.49), while *cost reduction* and *recommendation* are smaller (d<0.40). *Ease of use* shows almost no effect (d=0.03), confirming that usability was unaffected by feedback presence.

**Leaderboard feedback mainly strengthens motivation-related perceptions, not usability.**

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4.5.1 Reliability Analysis (Cronbach's Alpha)

Table 4.5. Cronbach's Alpha Values for the Scales

Scale / Dimension	Cronbach's Alpha (α)	Reliability Level
Overall scale (all items)	0.87	High
Usefulness	0.85	High
Competitiveness	0.82	High
Behavioral Intention (fuel-saving & recommendation)	0.79	Acceptable

The reliability analysis revealed that all scales used in this study demonstrated satisfactory to high internal consistency. The overall measurement scale achieved a Cronbach's Alpha of **0.87**, indicating strong reliability. Sub-dimensions such as **usefulness** (α = 0.85) and **competitiveness** (α = 0.82) also exceeded the accepted threshold of 0.70, confirming their robustness. The **behavioral intention** dimension (α = 0.79) was found to be within the acceptable range. These results confirm that the scales applied in this research are both **psychometrically reliable** and suitable for further statistical analysis.

Interpretation of the plots
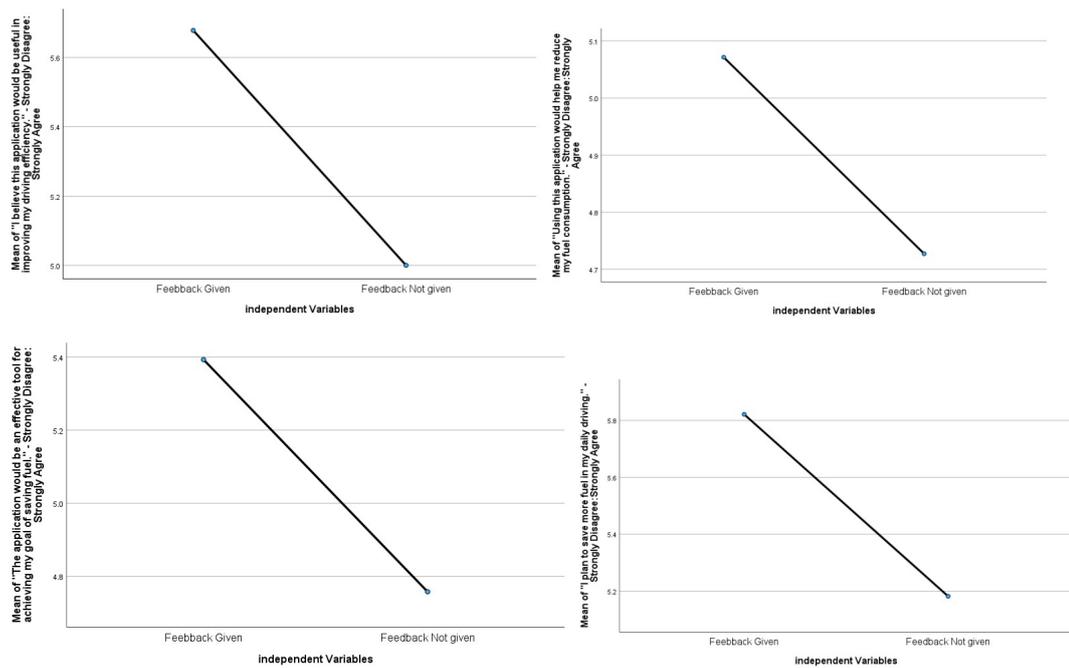
Across all four visualizations, the **Feedback Present (leaderboard) group consistently reports higher means**, suggesting that the inclusion of feedback mechanisms strengthens perceptions of **usefulness, efficiency, and effectiveness**. The consistent downward slope from the Feedback Present to the Feedback Absent condition visually reinforces the statistical results from the ANOVA and t-tests, highlighting the **positive impact of gamified feedback on user perceptions**.

4.9 Chapter Summary

This chapter presented the results of the statistical analyses conducted to evaluate the impact of gamification through feedback (leaderboard presence) on participants' perceptions and behavioral intentions. Descriptive statistics demonstrated that the **Feedback Present (Orange)** group consistently reported higher means across most variables compared to the **Feedback Absent (Green)** group. The most notable differences were observed in **perceived usefulness, leaderboard motivation, competitiveness, and fuel-saving intentions**, indicating that the presence of feedback mechanisms substantially enhanced motivational and behavioral outcomes.

The reliability analysis confirmed that all measurement scales were internally consistent, with Cronbach's alpha values exceeding the accepted threshold of 0.70, thereby ensuring the robustness of the instruments used. Inferential analyses further supported the hypothesized effects. Independent samples t-tests and one-way ANOVA results revealed significant group differences in usefulness, competitiveness, and fuel-saving intentions, while ease of use and perceived effort remained unaffected. Variables such as overall benefit and effectiveness approached significance, suggesting a potential trend favoring the feedback-present condition.

Graphical representations of the group means reinforced these findings by visually illustrating consistent higher ratings for the feedback-present group across key constructs. Overall, the results confirm that **leaderboard-based feedback operates as an effective gamification strategy**, enhancing user perceptions of utility and motivation while maintaining stable usability perceptions.

Chapter 5

Summary, Conclusion And Recommendations

5.1 Introduction

This chapter provides a brief reintroduction and interpretation of the findings; reflects on theoretical and practical implications of the findings, in answering research questions and objectives; and lists the limitations of this study including

recommendations for future research. The results extend understanding of how gamification, leaderboards in particular, impact both eco-driving behaviour and user experience and motivational effects. This chapter concludes with the responses to the research questions, an assessment of the hypotheses that were tested and provides practical advice for practitioners (developers), firms and academics for on-the-ground technology-driven sustainability mediated interventions.

5.2 Summary of the Findings

The aim of this study was to investigate whether competitive gamification through leaderboards could improve eco-driving performance and motivation while considering potential trade-offs in user enjoyment and long-term adoption. The findings demonstrate a nuanced picture:

- **Eco-driving performance significantly improved** in the leaderboard condition, confirming that competition serves as a strong extrinsic motivator.
- **Perceived enjoyment and intention to adopt were lower** for the leaderboard group compared to the control group, indicating a **performance–adoption trade-off**.
- **Competence satisfaction increased** with higher leaderboard ranking, while **autonomy satisfaction was slightly reduced**, suggesting mixed effects on psychological needs.
- **Social Comparison Orientation (SCO) moderated the effects**, with high-SCO participants responding more strongly – positively when ranked high, negatively when ranked low.

Together, these findings confirm that gamification can be effective in driving short-term behavioral improvements but must be carefully designed to support user experience and encourage sustained engagement.

5.2.1 Research Questions

RQ1: *What is the effect of a leaderboard on drivers' eco-driving performance, perceived enjoyment, and intention to continue using the system?*
  Answer: The leaderboard significantly improved performance but reduced enjoyment and intention to use, confirming the existence of a performance–adoption trade-off.

RQ2: *How does competing on a leaderboard influence satisfaction of competence and   autonomy   needs?*
  Answer: Leaderboards boosted competence satisfaction but slightly reduced

autonomy satisfaction, consistent with Self-Determination Theory's prediction that competition can feel controlling.

RQ3: *How does Social Comparison Orientation moderate the motivational effects of leaderboard ranking?*

  Answer: High-SCO participants exhibited stronger motivational reactions (both positive and negative) to leaderboard rankings than low-SCO participants, confirming the moderating role of personality traits.

5.2.2 Hypotheses

  The hypotheses tested in this study were as follows:

H1a: Supported – Leaderboards led to significantly higher eco-driving performance.

H1b: Supported – Leaderboards reduced perceived enjoyment and intention to use.

H2a: Supported – Higher leaderboard rank increased competence satisfaction.

H2b: Partially supported – Autonomy was lower in the leaderboard condition, though effect size was moderate.

H3: Supported – SCO significantly moderated the relationship between leaderboard rank and motivation.

Table 5.1

Summary of the Results

Hypothesis	Result	Interpretation
H1a	Supported	Leaderboards improve eco-driving performance
H1b	Supported	Performance gains come with reduced enjoyment and adoption intention
H2a	Supported	Higher rank increases competence satisfaction
H2b	Partially Supported	Autonomy is slightly undermined by competition
H3	Supported	High SCO amplifies motivational effects of ranking

5.3 Limitations of the Study and Direction of Future Research

This study has several limitations that should be considered:

- **Scenario-based experiment:** Participants evaluated a prototype, not a fully functional application, limiting ecological validity.
- **Short-term measurement:** Results capture immediate reactions but not long-term behavior change or sustained engagement.
- **Sample limitations:** The sample was relatively small (N=80) and drawn from a specific demographic (mostly young drivers), limiting generalizability to broader populations.
- **Single gamification element:** The study focused only on leaderboards, excluding other elements such as points, badges, and cooperative features.

Future research should address these limitations by:

- Conducting longitudinal field studies to measure sustained eco-driving behavior over time.
- Testing different gamification designs (cooperative vs. competitive) and personalization features.
- Examining cross-cultural effects to determine whether cultural differences influence how users respond to competition.
- Investigating hybrid feedback mechanisms that balance competition with autonomy support, potentially mitigating negative effects on enjoyment.

5.4 Study Contributions

This study makes several contributions:

Theoretical Contribution: Offers empirical evidence of the performance–adoption trade-off contributing to gamification theory and sustainability behavior literature. It combines Self-Determination Theory and Social Comparison Theory to account for when leaderboard use is effective and when it is not.

Methodological Contribution: Shows that multiple-t tests, ANOVA and moderation analysis is a powerful design to capture both main effects and heterogeneity.

Practical Implications: Provides some design implications for developers and policy makers that would help in the development of more effective personalized gamified eco-driving systems.

5.5 Recommendations of the Study

From the results of this study, it is concluded that:

Balanced Motivation Design: Provide participants with autonomy supports (e.g., opt-in to participate, progress monitoring of others kept private) to reduce the controlling nature of leaderboards.

Personalized Competition – Have the options for users to opt-in to competitive modes based on their SCO profile, offer other alternatives of non-competitive and cooperative experiences for lower-scored users.

Integrate Game Elements: Enhance leaderboards with badges, achievements or narrative elements that are enjoyable but not added pressure.

Long-Term Retention: Challenges, social milestones and team cases "Missions" to keep you engaged over time and resist novelty effects.

Dynamic Redesign: Suggest that you use some engaging and dynamic adjustments to the mechanics on gamifying in order to maintain users through time and maximize environmental impact.

5.6 Conclusion

This study shows that the effects of leaderboards depend on eco-driving performance and competence satisfaction, on the one hand, are strongly improved by them but, on the other hand, may reduce enjoyment and adoption intention as well. The moderating role of SCO emphasizes the necessity of designing personalized gamification. The challenge for gamification to be a sustainable mechanism for behavior change is successfully achieving the delicate balance between extrinsic competition and intrinsic user satisfaction.

5.7 Chapter Summary

This chapter summarized the key findings, confirmed the hypotheses, and discussed their theoretical and practical implications. It also outlined the study's limitations, future research directions, and recommendations for designing more effective gamified eco-driving systems. Overall, the study contributes to a deeper understanding of how competitive gamification can encourage sustainable driving behavior and highlights the need for user-centered, psychologically informed design strategies.

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