Toward a Gamified Mobile Application to Improve Eco-Driving: A Design and Evaluation Approach

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Abstract

The design and adoption of gamified information systems have been increasingly discussed in various fields of application such as education, health, crowdsourcing, or sustainability. We focus on the field of environmental sustainability and follow a design science research approach to develop and evaluate an instantiation of an artifact in the form of a gamified mobile application that supports eco-driving. In our research-in-progress, we propose the design of the artifact, which allows drivers to monitor their acceleration and braking performance. Through a situated implementation of two different gamification design elements, leaderboard and badges, the artifact encourages drivers to improve on their eco-driving behavior. We present an experimental design with which we plan to evaluate the artifact in a controlled setting using a driving simulator.

Keywords

Gamification, mobile application, eco-driving, Green IS, environmental sustainability, design science research, technology adoption.

Introduction

In recent years, the benefits of games have been increasingly recognized in academic research and industrial practice, which is why products and services that are not usually associated with games, are increasingly gamified (Müller-Stewens et al. 2017; Wolf et al. 2018). According to IEEE, gaming will be integrated into more than 85 percent of daily tasks by 2020 (PR Newswire 2014). Against this backdrop, we focus on the design and evaluation of gamified information systems, which are used in diverse fields of application such as education, health, crowdsourcing, or sustainability (Seaborn and Fels 2015). We focus on the field of environmental sustainability, specifically, we focus on smartphone-based systems that support eco-driving (Tulusan et al. 2012). Such systems provide visual displays showing the acceleration and braking performance that enable drivers to adjust their driving behaviors, which improves on eco-driving and thus leads to a reduction of fuel consumption (De Vlieger et al. 2000). We choose this setting of transportation because one quarter of worldwide carbon emissions is produced in the transport sector (International Energy Agency 2017), which makes transportation a relevant field of research for environmental sustainability. In this research-in-progress paper, we present a design and evaluation approach following Peffers et al.'s (2007) design science research methodology (DSRM) process model (see Figure 1).

Gamification Design Elements

We draw on a recent framework by Liu et al. (2017) who distinguish two main gamification design elements: **gamification objects** and **gamification mechanics**. *Gamification objects* are "the basic building blocks of a gamified system, which typically include items, characters, scripts, visual assets, and so on" (Liu et al. 2017, p. 1013). They are classified into two types of experiences: sensory experiences such as images, audios, videos, animations, and multimedia; and cognitive experiences such as stories, puzzles, and plots.

Gamification mechanics refer to "the rules that govern the interaction between users and game objects" (Liu et al. 2017, p. 1014). For example, a gamified system could contain points as an object, and the mechanic could be the rules for awarding the points to the user. Other mechanics may provide rules for chance elements, user choices, levels, leaderboards, badges, guilds, trading, and social interactions. The combination of gamification mechanics with actions taken by users, results in user-system interactions. In our study, we focus on leaderboards and badges, which are considered to be promising design elements for gamification (Hamari 2017; Höllig et al. 2018), and which we expect will help to improve on eco-driving behaviors.

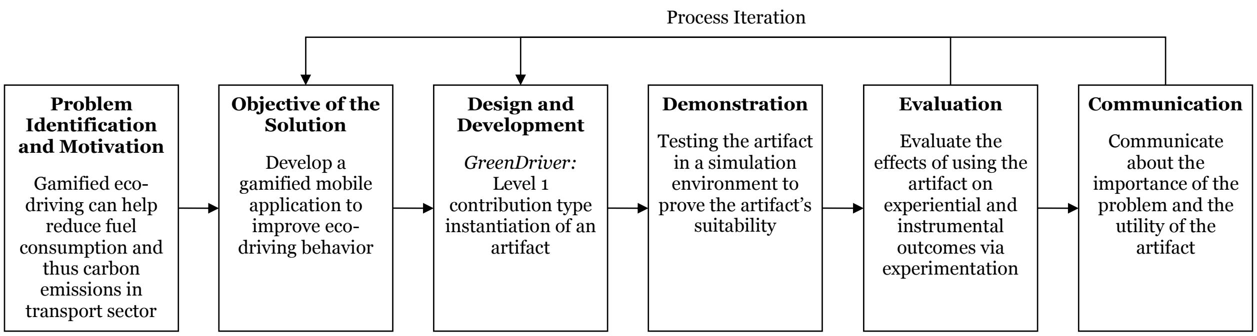

Figure 1. DSRM Process Model for a Gamified Eco-Driving Application

Research Approach

Designing the Artifact and Demonstration

For the design of the artifact, situated at the level 1 contribution type as a specific instantiation (Gregor and Hevner 2013), we used SIM Dashboard, a highly customizable app for Android smartphones and tablets. The app allows connection with driving simulators such as *Assetto Corsa* and *Project CARS* on a Windows PC, PlayStation 4, or Microsoft Xbox. For our gamified app called *GreenDriver*, we integrated a control bar for acceleration (displayed as a green bar), a control bar for braking (displayed as a red bar), a speed indicator in km/h in the middle of the app, and a fuel display in liters to allow drivers to monitor their fuel consumption. Figure 2a shows the proposed app in idle position.

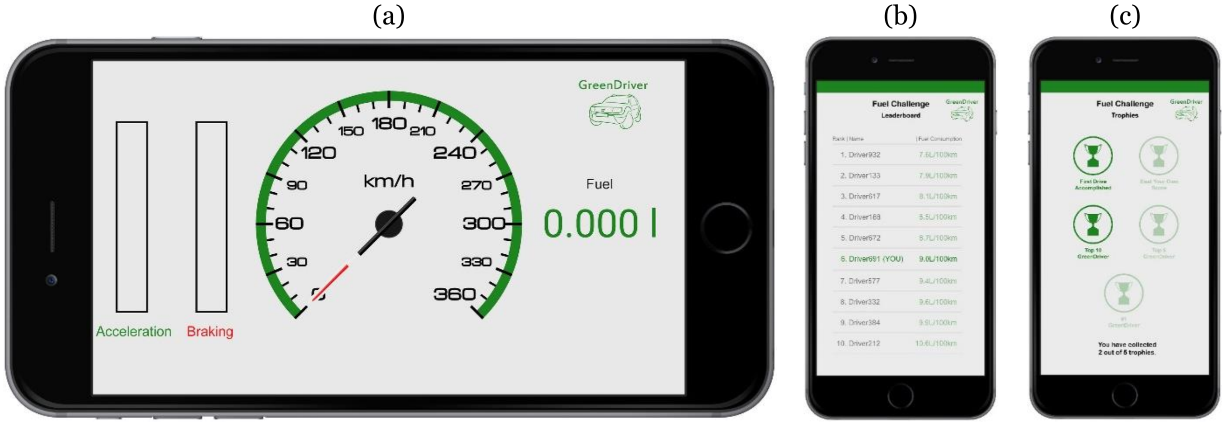

Figure 2. Proposed Gamified Mobile Application *GreenDriver*

For the gamification, we created a 'Fuel Challenge' for the *GreenDriver* app, and designed a leaderboard (see Figure 2b), which includes a ranking of drivers (gamification object) according to their fuel consumption in L/100 km (gamification mechanic). This ranking will provide drivers with comparative information about their eco-driving performance in relation to other drivers, which we expect will encourage them to drive more ecologically sustainable (user-system interaction). We further designed badges in the form of virtual trophies (gamification objects) (see Figure 2c), which are awarded to drivers based on five different tasks (gamification mechanics). Similar to the leaderboard, we anticipate that the badges will also allow to boost "green" driving behaviors (user-system interaction).

To demonstrate and prove the artifact's suitability, we tested the artifact in a simulation environment. For this purpose, we chose the driving simulator *Project CARS* on a PlayStation 4, and connected the app with the simulator. In order to establish a more naturalistic driving environment, we implemented the steering wheel Logitech G29, which has a 900-degree lock-to-lock rotation (which is a similar degree of motion as a steering wheel inside a car), and which provides force feedback to the operator (which applies actual forces, not just simple vibration, to increase the authenticity of the haptic interface). We then conducted several test drives with the simulator, which verified the suitability for our study.

Evaluation via Experimentation

We plan to evaluate the artifact by means of a 2 (with/without leaderboard) × 2 (with/without badges) between-subject, full-factorial experimental design. Experiments are considered as an effective method to evaluate artifacts in controlled environments (Hevner et al. 2004). All participants will be shown the same information with the difference that one group will be exposed to both leaderboard and badges, two groups will have one gamification element each available, and one group will only receive fuel consumption in L/100 km at the end of the test drive (control group), which will be available to the other groups as well. Through our experiment, we expect to create user interactions with the artifact to engage users with the gamified app and produce desirable outcomes (improved user experience and reduced fuel consumption). The engagement that results manifests in experiential and instrumental outcomes, which creates *meaningful engagement* for users (Liu et al. 2017). Since research suggests that the effect of gamification diminishes with time (Koivisto and Hamari 2014), we will assess our hypotheses at two points in time: after a first round of test drives (t_1), and after a second round of test drives (t_2). Figure 3 shows our research model.

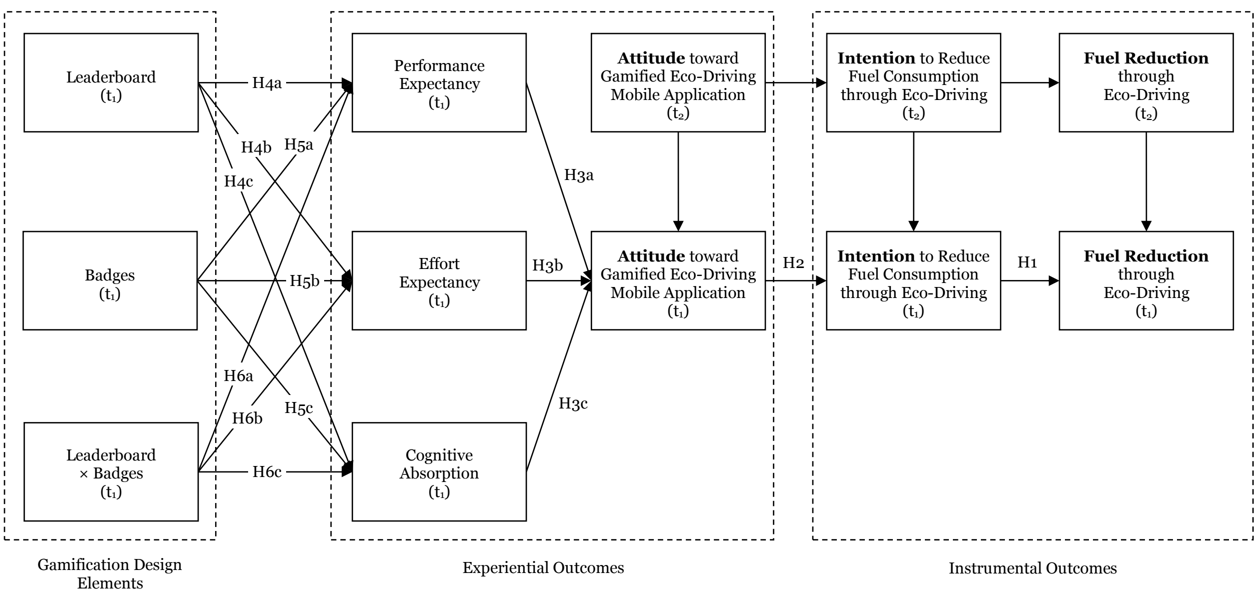

Figure 3. Research Model for Empirical Evaluation

Instrumental outcomes refer to salient consequences situated within the context for which the artifact was developed (Liu et al. 2017), in our case the reduction of fuel consumption during car operation. Thus, we will measure fuel consumption, which we hypothesize will be influenced by the intention to reduce fuel consumption through eco-driving:

H1: Intention to reduce fuel consumption through eco-driving will positively influence fuel reduction.

Experiential outcomes refer to outcomes in the form of flow, cognitive absorption, enjoyment, cognitive effort, and other similar outcomes (Liu et al. 2017). To measure how experiential outcomes are influenced by gamification elements, we draw on the construct of performance expectancy (expected eco-driving performance through gamification) and effort expectancy (expected ease of use of the gamified system) (Venkatesh et al. 2003). We add cognitive absorption as a third construct, which is based on flow theory (Csikszentmihalyi 1990) and is considered as an experiential outcome (Liu et al. 2017). Cognitive absorption is defined as a state of deep involvement with the system (Agarwal and Karahanna 2000; Lowry et al. 2013), which is depicted through five dimensions: temporal dissociation ("the inability to register the passage of time while engaged in interaction"), focused immersion ("the experience of total engagement where other attentional demands are ignored"), heightened enjoyment ("the pleasurable aspects of the interaction"), control ("the perception of being in control over the interaction"), and curiosity ("heightened arousal of cognitive and sensory curiosity") (Santhanam et al. 2016, p. 457). We expect that performance expectancy, effort expectancy, and cognitive absorption will influence users' attitude toward the gamified app, which in turn will affect the intention to reduce fuel consumption through eco-driving. We propose the following hypotheses:

H2: Attitude toward the gamified mobile application will positively influence the intention to reduce fuel consumption through eco-driving.

H3: Attitude toward the gamified mobile application will be positively influenced by (a) performance expectancy, (b) effort expectancy, and (c) cognitive absorption.

By manipulating our leaderboard and badges treatments through the presence and absence in the gamified app, we anticipate that performance expectancy, effort expectancy, and cognitive absorption will be influenced. We further hypothesize that combining both instances will amplify the effects of leaderboard and badges, because the ranking component of the leaderboard and the tasks linked to the badges closely relate to each other forming a complementary entity when combined.

H4: The gamification design element of leaderboard will positively influence (a) performance expectancy, (b) effort expectancy, and (c) cognitive absorption.

H5: The gamification design element of badges will positively influence (a) performance expectancy, (b) effort expectancy, and (c) cognitive absorption.

H6: A combined instance of the gamification design elements of leaderboard and badges will lead to an interaction effect, which will influence (a) performance expectancy, (b) effort expectancy, and (c) cognitive absorption even more positively.

Expected Contributions and Limitations

While research on eco-driving assistance systems has increased in the last few years (Jamson et al. 2015), there is scarce literature on gamified eco-driving systems (for a gamified application on safe driving, see Steinberger et al. 2017). Through our design and evaluation approach of the proposed gamified mobile application for improved eco-driving, we expect a contribution to the gamification and eco-driving literature. Our study will further contribute to the ongoing discussion how gamified information systems can create meaningful engagement through experiential and instrumental outcomes (Liu et al. 2017). Thus, we also expect a contribution to the IS adoption and use literature as well as the Green IS literature by addressing the gap of how the adoption and use of IS can lead to instrumental outcomes, in our context the reduction of fuel consumption and thus the reduction of carbon emissions. We are currently finalizing our experimental design and hope to report initial empirical results at the conference.

As with every study, there are limitations, of which we acknowledge two at this point. First, for the design of the artifact, we focus on two gamification design elements: leaderboard and badges. While there are numerous other gamification elements (Zichermann and Cunningham 2011), we limit the number of elements to two, which at the same time limits the scope, yet improves the conciseness and testability of our study. Second, for the evaluation, we will test the artifact in a controlled experiment with a driving simulator. This limits the driving experience compared to real-life driving environments, however, there will be advantages regarding liability, practicability, and a controlled setting with identical conditions for all participants (same route with exact same traffic conditions).

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