Promoting green mobility through gamified transportation campaigns

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Abstract

This paper explores the impact of gamified campaigns within the AirBreak project on promoting sustainable urban mobility. Designed to induce lasting behavior change, the campaigns target diverse scenarios, including home-to-work, home-to-school, and leisure travel. The study assesses the overall effectiveness of these campaigns, analyzing changes in individual mobility choices and their contribution on reducing CO_2 emissions. Additionally, the paper delves into the motivational aspects of the campaigns, identifying features that influenced participants towards sustainable mobility. Understanding these motivational factors provides insights into key elements driving positive behavioral changes. Moreover, the research investigates user characteristics influencing consistent engagement in sustainable mobility choices. This analysis enhances our understanding of the factors shaping participants' inclination towards adopting and sustaining eco-friendly travel practices. Grounded in theoretical foundations, the study details data collection and analysis methods, presenting findings that offer valuable perspectives for future interventions and policy considerations in the context of gamified sustainable transportation campaigns.

Keywords

gamification, green mobility, green transportation, behavior change, sustainability

1. Introduction

Mobility assumes a crucial role in contemporary urban settings, shaping the way citizens engage with the city, access essential services, and participate in urban life. The effectiveness and organization of mobility, as highlighted by Vesco et al. [1], significantly influence citizens' experiences within the city. In this dynamic context, cities grapple with a formidable challenge. Administrators must not only ensure citizens' right to mobility and seamless access to local services, but also strive to minimize the economic, social, and environmental costs associated with the mobility system. Addressing this challenge necessitates a comprehensive approach that efficiently leverages existing mobility resources while integrating and promoting new or emerging mobility services, fostering an integrated, efficient, and sustainable mobility ecosystem [2]. In pursuit of this objective, cities are strategically planning and implementing interventions across infrastructures, services, and mobility policies. While these elements are pivotal in advancing sustainability and integration in mobility, it is crucial to recognize the equally significant socio-technical dimension of user acceptance and adoption [3, 4]. Innovative policies, infrastructures, and services run the risk of falling short if not complemented by initiatives aimed at increasing citizens' awareness and involvement in the transformative process, influencing their mobility habits in a gradual yet profound manner [1].

In many instances, citizens' everyday mobility decisions are shaped by ingrained habits and influenced by inaccurate or outdated beliefs [5]. It is essential for citizens to be well-informed about the mobility services available in their city and their actual value, encompassing considerations such as time, cost, and environmental impact. A heightened awareness is necessary for individuals to recognize the repercussions of their daily choices, including their impact on traffic, greenhouse gas emissions, and social costs [6]. Crucially, citizens should perceive themselves as integral to a community where their collective daily choices play a pivotal role in advancing city-level mobility strategic objectives [7]. In essence, individuals and communities must cultivate a sense of responsibility, contributing to the development of a new cultural paradigm for both urban and rural mobility.

In recent years, substantial efforts have focused on utilizing interactive technologies to enhance citizen awareness, promote active participation, and induce behavior change toward a more sustainable lifestyle. Gamification, identified as a persuasive technology with significant potential [8, 9], is increasingly

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recognized for its applicability in the mobility domain [10, 11, 12, 13, 14, 15], as well as in various other environmental sustainability domains [16, 17, 18, 19]. The core concept involves harnessing the motivational and persuasive influence of games through the design of systems that effectively utilize and integrate game concepts and elements [20, 21]. Gamified systems incentivize individuals to make specific decisions or perform essential tasks, crucial for achieving valuable objectives [22]. This transformation occurs by converting potentially unattractive actions into enjoyable and rewarding experiences [21].

The development of urban mobility policies has become crucial for governments and stakeholders aiming to support sustainability goals [23]. Research indicates that active and sustainable mobility can play a vital role in reducing greenhouse gas emissions [24]. Despite the societal and individual advantages of active mobility, there is a challenge in convincing people to shift from car-centric lifestyles [25]. Therefore, we implemented two gamified sustainable mobility campaigns providing more incentives for users to adopt environmentally sustainable methods of travel.

The two campaigns, incorporated within the AIR-BREAK project[2], have been designed and implemented across various contexts such as commuting between home and work, home-to-school travel, leisure activities, and free time mobility. The aim of this initiative is not only to alter users' mobility patterns during the campaign but also to instill a lasting behavior change.

In this paper, we present an exhaustive description of the AIR-BREAK project and the implemented campaigns (Section 2). In Section 3, we present the theory and hypotheses that guide this paper. In Section 4, we introduce the methods used for the questionnaire creation and evaluation, data collection, and statistical analysis. Then, in Sections 5 and 6, we report and discuss the findings after the analysis. We conclude the paper with the conclusions and future works related to the AIR-BREAK project in Section 7.

2. The AIR-BREAK Project

The AIR-BREAK project is centered on the core objective of informing and heightening citizens' awareness about sustainable mobility services*, with the goal of fostering the adoption of eco-friendly travel habits*. In outlining the project's scope, various campaigns have been designed to address four key objectives. Firstly, the project endeavors to *actively engage citizens*, making them aware of both existing and newly introduced mobility resources. Simultaneously, efforts are directed towards elevating their awareness regarding the significant impact their daily mobility choices can have. The ultimate ambition is to contribute to the establishment of a new cultural norm for urban and rural mobility within the city community. Building on this foundation, AIR-BREAK seeks to instigate a *voluntary travel behavior change*. This is achieved through a strategic blend of virtual (game-based) and tangible incentives, leveraging personalized cooperative and competitive game mechanics. The goal is to encourage and sustain the adoption of more sustainable mobility habits among the populace. Moreover, AIR-BREAK focuses on *community building*. By actively involving citizens in AIR-BREAK initiatives and events, the project aims to foster the creation of a local community of users. Tailored behavioral change programs are deployed to reach diverse user segments, including primary, secondary, and high school students, as well as employees. The intention is to create synergies with other AIR-BREAK initiatives, promoting a collaborative and supportive environment. Finally, AIR-BREAK emphasizes the importance of *producing measurable outcome*s. This entails evaluating the project's impact in terms of engagement, retention, increased awareness, and behavioral change. The insights gained from these measurable outcomes will be instrumental in refining and optimizing subsequent phases of the AIR-BREAK project, ensuring continuous improvement based on real-world experiences.

Within the framework of the AIR-BREAK project, we have conceptualized and executed diverse sustainable mobility campaigns focusing on distinct mobility contexts, including *home-to-work mobility*, *home-to-school mobility*, leisure, and *free time mobility*. These initiatives cater to a range of end-user groups, encompassing the general public, students, and employees. The subsequent section provides a concise overview of each of these planned actions. AIR-BREAK mobility campaigns have been implemented through the Play&Go platform that supports the definition and management of different types of sustainable mobility campaigns, customizable with respect to mobility objectives and target users. The customization of campaigns can concern: the means of mobility to be promoted, the travel validation criteria, the competitive/cooperative game elements implemented, and the real incentives provided by the campaign [26]. Users interact with the system through the Play&Go App (see Figure 1), which supports various functionalities. In addition to player registration, discovering and registering for active campaigns, managing the player's profile, and inspecting campaign results, the app incorporates a robust tracking system able to track single and multimodal sustainable trips. This system collects journey data to assign rewards, modify the game status for players based on their activities, and calculate the reduction in CO_2 emissions associated with sustainable transportation choices instead of car use. The app employs a specific formula that considers the kilometers traveled using different sustainable transportation means available in various mobility campaigns. Furthermore, users can access information on weekly and global rewards, as well as the rules and regulations of different campaigns and engage in filling out questionnaires. This multifaceted approach enhances user engagement, promotes sustainable mobility practices, and contributes to both individual rewards and environmental conservation efforts.

[2] https://airbreakferrara.net/

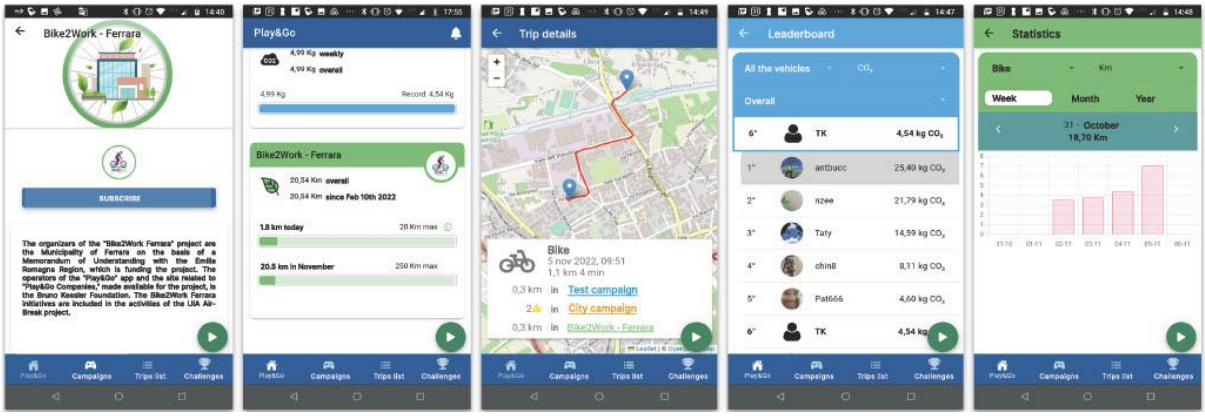

Figure 1: The Play&Go App.

2.1. Urban Mobility Campaign

The *Urban Mobility Campaign* (UMC) is an initiative encouraging citizens to actively embrace sustainable transportation through gamification. Registration and utilization of the Play&Go app for tracking eco-friendly trips are essential components of engagement. Central to the gaming experience in the UMC are the *Eco-Leaves Points*. These points serve to keep the user motivated [27] and as a cornerstone for progression in both weekly and global *leaderboards* [28], thereby influencing the allocation of weekly and final prizes. Earned for each *tracked and validated sustainable trip*, the calculation hinges on factors such as the distance covered and the sustainability of the chosen means of transportation. The core mechanics of the game revolve around trip tracking, wherein players specify their mode of — be it walking, biking, public transportation, or car-pooling. An automatic validation process ensures the accuracy of each trip, avoiding potential game abuse [26].

A thoughtful design choice involves the introduction of daily limits on tracked kilometers and trips to prevent disproportionate and unnecessary use of transportation means. This limitation ensures a more equitable gaming experience for all participants, narrowing the performance gap between top players and others actively engaged in the campaign. Furthermore, constraints tied to the validity of tracked trips based on location — valid only if the origin or destination falls within the specific territory — add an additional layer of relevance and authenticity to the gameplay. Beyond the core mechanics, players have opportunities to earn bonus Eco-Leaves points. These incentives include inviting friends to join the game, achieving success in *weekly challenges*, and obtaining special badges that come with associated Eco-Leaves bonuses. Participants can meticulously monitor their mobility history and achievements through personalized profiles, which showcase a diverse array of *badges* symbolizing accomplishments. These badges range from achieving specific Eco-Leaves milestones to showcasing preferences in transportation modes, reinforcing the exploration of various mobility alternatives [29].

Distinguishing itself from a one-size-fits-all approach, the UMC thrives on its highly *personalized weekly challenges*. This personalization is achieved through a Recommendation System, ensuring that challenges are not only motivating but also realistic, avoiding frustration stemming from unattainable targets [30]. The game seamlessly integrates both *single-player* and *multiplayer challenges*, catering to a diverse range of player preferences. Single-player challenges span various types, including *performance-based*, *repetitive behavior*, *surveys*, and *events*, each contributing to the player's Eco-Leaves points. In multiplayer challenges, players experience a sense of community and relatedness. These challenges come in cooperative, time-based competitive, and performance-based competitive modes. *Cooperative challenges* necessitate cumulative effort from participants, fostering a collaborative spirit. Meanwhile, *competitive challenges* introduce a captivating dimension with fixed targets, time constraints, and performance-based criteria.

A pivotal aspect of the UMC is the continuous evaluation of player performance through *game levels*. Players progress through different levels such as *Green Lover*, *Green Warrior*, and *Green Guru* based on the total points they accumulate. Importantly, this system ensures that certain features of the game become available to players upon reaching specific levels, adding an element of progression and achievement to the gaming experience. The gameplay adopts a weekly structure, fostering a sense of regularity and allowing for the creation of *weekly leaderboards*. These leaderboards, reflecting performance within a specific time-frame, contribute to the excitement of weekly prizes offered by local sponsors. Importantly, this structure provides newcomers with a fair opportunity to compete with seasoned players, leveling the playing field and maintaining a vibrant gaming community. To incentivize sustained participation, the UMC concludes with final prizes awarded to top players on the global leaderboard. Both weekly and final prizes are generously offered by local associations and sponsors, enhancing the overall appeal of the campaign.

2.2. High School Challenge

The *High School Challenge* (HSC) is a competition designed for high school classes, with the goal of encouraging sustainable and active commuting from home to school. Participants utilize the Play&Go

application to track their eco-friendly journeys. Each student not only competes individually in the UMC but also contributes to their class's overall standing in the inter-school competition. Attractive prizes await the most active and sustainable classes. The class registration process involves the following steps, facilitated by a designated reference teacher:

1. Participants download the Play&Go application and register for the game.
2. The reference teacher, using an institutional email account, communicates the group data through the registration form.
3. Teams are formed to compete in the competition's rankings.

Teams must comprise students from the same class, with a minimum of 10 students per team or the entire class for classes with fewer than 10 students. Classes achieving at least 90% participation receive an initial bonus of 300 Eco-Leaves points. Teachers interested in joining can also be part of the class team, with a limit of one team per teacher. Participants continue to use the Play&Go application to track their sustainable journeys. Each participant not only competes individually but also contributes to their team's performance in the inter-school competition. In this competition, all Eco-Leaves points earned by team members throughout the competition's duration using the Play&Go App are considered. The team accumulating the highest number of Eco-Leaves points, calculated as the average value of its members, emerges as the winner.

Throughout the competition, the global leaderboard of classes can be accessed via the Play&Go App and the AIR-BREAK website. Upon the competition's conclusion, the teams leading the HSC Global Eco-Leaves Points Rankings will be awarded collective prizes.

3. Theory and hypotheses

Given the various gamified campaigns in the AIR-BREAK project, all aligned with a common theme, we identified the need to develop a cross-sectional questionnaire applicable across all campaigns that incorporate game elements. From a long-term analysis of previous campaigns [31, 32], we identified a different interaction between factors in relation to the nature of different rewards and game elements, and specific correlations between some factors, such as campaign appreciation and behavioral change. Therefore, we decided to base the new questionnaire on specific relationships. Then, we formulated three research questions.

RQ1. To what extent was the campaign effective in enhancing participants' sustainable choices in terms of mobility?

RQ2. Is the preference for specific features of the campaign related to users' motivation in making sustainable choices in terms of mobility?

RQ3. Are there any characteristics of the users that make them more prone to appreciate the campaign?

The first research question stems from the fact that the use of a gameful system does not mean guaranteed success [20, 33]. Then, it is crucial to report whether the campaign was effective in enhancing participants' sustainable choices in terms of mobility. The second research question stems from the need to identify whether specific elements could be useful in the creation of future sustainable mobility campaigns. The last research question is based on data in the literature [34, 35, 36] suggesting that users' demographic characteristics can modulate their appreciation for gameful systems.

4. Methods

4.1. Questionnaire development

Two questionnaires were used to evaluate users' appreciation for the campaign and behavioral change in terms of sustainable mobility. The first pre-campaign questionnaire consists of six categorical items related to the background information on users' preferences for means of transportation — including bus, train, bike, walk, and car —, and one categorical item for information about the app. The post-campaign questionnaire repeats the same questions as the first one, and then, for the core part, a model with five latent and 13 manifest variables was formulated following the results of previous campaign analyses [31, 32]. These items were collected using a 5-point Likert-scale with a magnitude from 1 (Disagree) to 5 (Agree). Lastly, three open questions collected detailed information on appreciated and non-appreciated elements of the campaign[3]. The theory of the core part consisted of five core constructs: *intrinsic motivation* (**IM**), *extrinsic motivation* (**EM**), *behavior change* (**BC**), *tool attractiveness* (**TA**), and *future behavior* (**FB**), and a single item for the evaluation of the *Overall appreciation* (**OA**). Moreover, items related to the appreciation of game elements (**TA2** — *[Specific game element] made it enjoyable to participate in the [campaign] initiative*), and those related to behavior change due to game elements (**BC3** — *[Specific game element] prompted me to go more often by environmentally friendly means*) were repeated for each game element entered into the campaign to assess how much specific game elements contributed to campaign appreciation and actual behavioral change.

4.2. UMC participation

The UMC (introduced in Section 2.1), ran from April 17, 2023, to September 24, 2023. Ferrara citizens tracked their sustainable movements through the Play&Go app, including cycling, walking, taking the bus, train, or carpooling. Participants actively took part in personalized mobility challenges, striving to climb the rankings and win various weekly and final prizes. The results of the campaign have been highly

[3] The full questionnaire can be retrieved here: https://osf.io/6mrga/?view_only=d9ecfb3b679e41ecbb0fde89404b2e7b

encouraging in terms of participation. As depicted in Figure 2, a total of 258 citizens joined the initiative, with 55% being women and 45% men. In terms of age distribution, participants between the ages of 35-50 accounted for 37.8%, while those in the 20-35 age group constituted 17.07%. Individuals between the ages of 50-70 comprised 43.9%, and those under 20 made up 1.22%. To provide us with detailed feedback on their enjoyment and effectiveness in behavioral change, the questionnaire was sent to participants at the end of the campaign.

Figure 2: UMC Participation and Impact.

4.3. HSC participation

The HSC (introduced in Section 2.2) lasted from April 3 to June 4, 2023, and utilized the Play&Go App. Through this application, students and teachers tracked their sustainable movements (cycling, walking, bus, train, or carpooling), engaging in team play, and climbing the rankings to win final prizes.

Figure 3: HSC Participation and Impact.

Notably, the HSC featured 7 teams (see Figure 3), with 5 teams composed of students and 2 teams consisting of teachers, adding a collaborative dimension to the challenge. The overarching goal of the HSC was to promote sustainable commuting between home and school, as well as during leisure time, for all students aged 14 and above. This objective was achieved through cooperative efforts within classes and inter-class competition among high schools. To provide us with detailed feedback on their enjoyment and effectiveness in behavioral change, the questionnaire was sent to participants at the end of the campaign.

4.4. Confirmatory factor analysis

Before analyzing the data comprehensively, we carefully checked the theoretical arrangement of the items against the data obtained through a confirmatory analysis, and then grouped the items differently within the questionnaire. Confirmatory factor analysis (CFA) is employed to assess and potentially refine a predefined model depicting the relationships between latent variables (factors) and observable (or measured) variables. CFA falls under the umbrella of Structural Equation Modeling (SEM), a statistical method that amalgamates multivariate techniques such as regression analysis and factor analysis. SEM investigates the connections among variables, encompassing both observable and latent ones, within a model specified by the researcher based on theoretical considerations and prior findings. The model parameters are typically estimated using techniques like maximum likelihood from the covariance matrix of the observable variables [37, 38]. Statistical evaluation of model fit is often performed using the chi-square (χ^2) goodness-of-fit test. Additionally, the Root Mean Square Error of Approximation (RMSEA), derived from the χ^2 test, provides a measure on an absolute scale, reflecting the model's fit to the data while considering factors such as model size and sample size. In this study, RMSEA values below 0.05, Comparative Fit Index (CFI) values above 0.96, and Standardized Root Mean Square Residual (SRMR) below 0.08 are considered indicative of a satisfactory fit [37, 39, 40], indicating that there is no need to arrange items and the structure differently.

Lastly, many authors do not rely on the analysis of χ^2 value and its significance, as it is highly subject to sample size [41]. We therefore preferred to rely on the ratio of chi-square to degrees of freedom (df). Values less than 2 are often considered acceptable. MPLUS (version 8.4)[4] was used to run the CFA.

4.5. Questionnaire analysis

4.5.1. Participants

We examined information gathered from 117 participants (female = 67, aged between 16 to 70 years old), who actively participated in two campaigns: HSC (N = 26) and UMC (N = 91), and completed the final questionnaire through Google Form. Of the 117 participants who completed the final questionnaire, 74 (all from the UMC campaign) had also completed a pre-campaign questionnaire.

4.5.2. Analysis

We proposed an analysis method for the questionnaire. Not to weight the number of items related to the number of game elements, any item related to the appreciation of game elements was averaged (**TA2**), as were those related to behavior change due to game elements (**BC3**). In addition, as defined in other scales, such as MEEGA+ [42], and SUS [43], we identified a unique final value to provide a holistic evaluation of the campaign, defined as "*total score*", ranging from 0 to 1, based on the formula $\overline{X}/5$, where $\overline{X}$ represents the mean of the answers calculated for each user. The choice of this formula falls back on the fact that, thanks to the 5-point Likert-type answers, it is possible to obtain a score ranging from 0 to 1, making it feasible to create a priori thresholds for campaign satisfaction, and because a successful sustainable mobility campaign assumes that game elements and the platform have been implemented properly to support behavioral change during the campaign, and in the long term. Furthermore, these elements succeed in

[4] https://www.statmodel.com/

motivating users who are driven by intrinsic or extrinsic motivation equally. The choice of using a total comprehensive score stems from the need for unambiguous value to understand how successful sustainable mobility campaigns have been perceived. The questionnaire's design allows for the evaluation of how various game elements impact campaign appreciation and user motivation. Additionally, it facilitates the summary, on one hand, and comparison, on the other, of the distinct campaigns within the AIR-BREAK projects. While a more in-depth analysis of each individual campaign is planned for the future, this paper concentrates on the overarching aspects shared by both campaigns. To answer to RQ1, we evaluated the effectiveness of the campaign by comparing participants' sustainability scores at the beginning and at the end of the campaign through a Wilcoxon test for paired samples. Sustainability scores were calculated using the following formula:

$$\frac{(bus + train + bike + walk)/4 + (7 - car)}{2}$$

with *bus*, *train*, *bike*, *walk*, and *car* being participants' answers to a 6-point Likert scale on their mobility habits (1 = almost never, 6 = more than once a day). We examined participants who completed both the initial and final questionnaires to assess the effectiveness of the platform and gain insights into how users' habits before using the app might impact post-results. We ran a series of Spearman correlations between EM, IM, the total score and (i) pre-sustainability scores, (ii) post-sustainability scores, and (iii) Δ scores, representing the difference between pre and post campaign scores. Furthermore, a Wilcoxon test was used to compare participants' scores in the EM and IM constructs. To answer to RQ2, we analyzed participants' open-ended responses to the question "*What did you like the most about the campaign?*" we categorized them into two groups based on their answers. Users' answers were short and referred to specific elements of the campaign (e.g., "rewards", "points", "the initiative", "the idea"). We used a Mann-Whitney test to compare participants' total scores. Then, we ran a rank-transformed ANOVA to compare IM and EM scores based on the elements users valued most. Finally, to answer to RQ3 a rank-transformed ANOVA was used to explore whether demographic characteristics, such as age and gender, influenced users' total scores.

5. Results

5.1. Participation results

During the UMC campaign, exploiting the Play&Go app, nearly 31,000 journeys have been recorded that covered over 148,000 sustainable kilometers, with over 95,000 by bike and almost 15,000 walking (resulting in zero impact) (see Figure 4). The experiment demonstrated the ability to sustain citizens' motivation in long-term campaigns, with continuous and consistent participation over the initiative's duration of more than 5 months. Exploiting the post-campaign survey and in particular, analyzing items related to behavior change (items BC1 and BC2), the results showcased the capacity to change players' behaviors: 94% of players stated they felt motivated to adopt more sustainable mobility habits. Specifically, 79% incorporated sustainable mobility habits into their daily commutes, and 77% for leisure travel. Finally, a significant outcome is the participants' satisfaction, with 98% expressing a definite willingness to participate in future editions (item FB2). This initiative also led to the formation of a local community of motivated and active users advocating for more sustainable mobility.

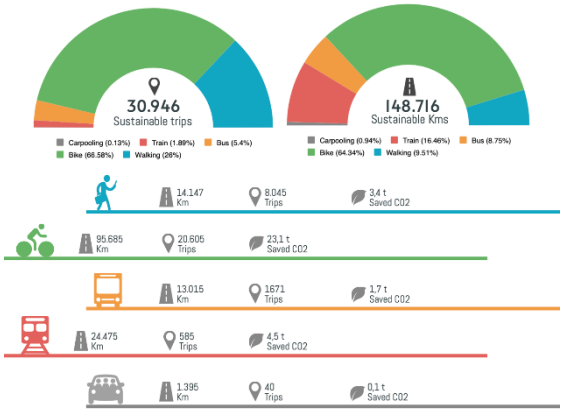

Figure 4: Use of different transportation means in UMC.

For what concerns the HSC campaign, more than 100 students and teachers have participated in the HSC initiative, with over 3,000 tracked journeys, in Play&Go, covering more than 9,000 sustainable kilometers (of which 27% were by bike and another 27% walking - zero impact), and nearly 2 tons of CO_2 saved (see Figure 5). Analyzing the post-campaign survey, the experiment has demonstrated the ability to change players' behaviors (items **BC1** and **BC2**): almost 70% of players claim to have adopted more sustainable mobility habits in their home-school (or home-work) commutes, while 75% have improved their habits during leisure time. Finally, an important result (item **FB2**) is the satisfaction of the participants (70% express a desire to participate in future editions) and the creation of a local community of motivated and active users for more sustainable mobility.

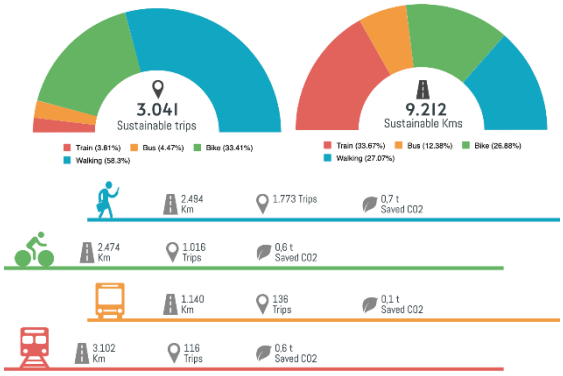

Figure 5: Use of different transportation means in HSC.

5.2. Questionnaire results

The test statistics for this model were RMSEA = 0.039, χ^2/df = 1.176, CFI = 0.986, and SRMR = 0.050. These results indicated that the model fit was good (Figure 6). The data also indicated significant relationships between several latent factors, however, two hypothesized relationships (IM-BC, and EM-TA) were not significant, so they were not reported in the model structure. See Table 1 for a comprehensive overview. The results show that users' behavior change can be explained by extrinsic motivation, thus conveyed primarily by the rewards, while tool and game elements' attractiveness seem to be explained by intrinsic motivation. Interestingly, the future behavior is explained by both users' expressed behavior change values and tool attractiveness. As hypothesized, tool appreciation and behavioral change reports go hand in hand. Lastly, the final score for the campaign's overall appreciation, related to the item "Participating in [campaign] was enjoyable overall", is explained by the interaction with tool attractiveness and future behavior. Based on these data, we were able to proceed with the inferential analysis without having to change the theoretical structure of the questionnaire and without removing/changing items.

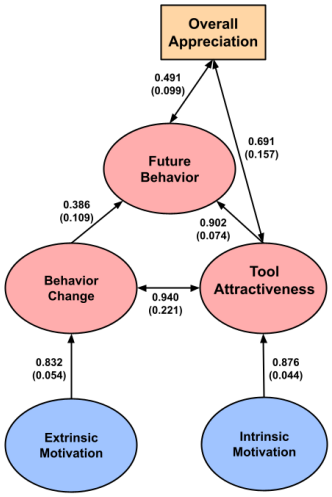

Figure 6: Final model with significant standardized.

Path	STDYX Estimators	S.E.
IM ⇒ TA	**0.876***	0.044
IM ⇒ BC	0.030	0.126
EM ⇒ TA	0.030	0.130
EM ⇒ BC	**0.832***	0.054
BC ⇔ TA	**0.940***	0.221
BC ⇒ FB	**0.386***	0.109
TA ⇒ FB	**0.902***	0.074
TA ⇒ OA	**0.691***	0.157
FB ⇔ OA	**0.491***	0.099

Table 1: Standardized estimators between factors. *p < 0.001

We used R v4.3.1[5] to run the analyses. Participants' overall score in the questionnaire indicates a good appreciation for the project (N = 117, M = 0.797, SD = 0.147). As is often the case with questionnaire data with Likert-type scales [44], no data were normally distributed within the measured variables. First of all, we were interested in understanding the increase in participants' sustainability choices in terms of transportation, and how their old habits are related to their final overall score, along with the five constructs (RQ1). To achieve this, we included in the analysis those participants who completed both the pre- and post-campaign evaluations (N = 74, due to missing answers in the pre-campaign evaluation. All 74 participants are from the UCM campaign). Given the non-normal distribution of the data, non-parametric tests were employed for the analysis (refer to the supplementary material for normality analyses[6]). We utilized a Wilcoxon test for paired samples to compare sustainability scores based on participants' habits in terms of sustainable mobility before and after using the application. The results revealed a significant difference in participants' sustainable habits before and after using the application (W = 371.5, p-value < 0.001). Additionally, a series of Spearman correlations were conducted between EM, IM, and (i) pre-sustainability scores, (ii) post-sustainability scores, and (iii) Δ scores, representing the difference between pre and post-sustainability scores. This aimed to assess the relationship between intrinsic and extrinsic motivation and participants' eco-friendly habits. A significant negative correlation was identified between pre-scores and the extrinsic motivation (EM) construct (Figure 7; S = 83142, p-value = 0.047, ρ = -0.231).

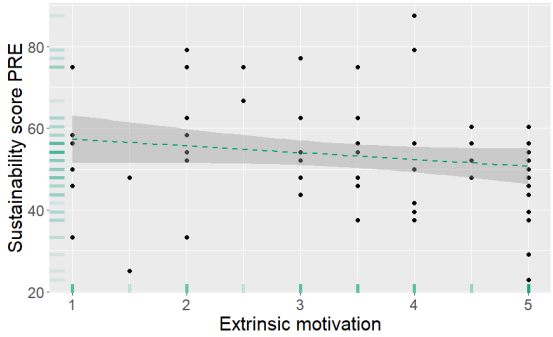

Figure 7: Correlation between participants' sustainability habits score before the campaign and their score in the extrinsic motivation construct at the end of the campaign.

Importantly, no correlation was found between pre-scores and the overall score, suggesting that the campaign's appreciation is independent of participants' previous habits in sustainable transportation. Finally, no correlations were observed between the other constructs and (i) pre-scores, (ii) post-scores, and (iii) Δ scores. Then we confronted participants' scores in the extrinsic motivation (EM) and intrinsic motivation (IM) constructs (N = 117). Also, in this case, we had to opt for a non-parametric test since data did not distribute normally. A Wilcoxon test highlighted a significant difference between the

[5] https://cran.r-project.org/bin/windows/base/

[6] Supplementary material

two constructs, with IM being higher than EM (Figure 8; W = 539, p-value < 0.001).

To answer RQ2, we analyzed participants' responses to the question "*What did you like the most about the campaign?*" Forty-nine (49) participants did not reply to the open question (or replied "all" or "nothing"). Notably, a significant number of participants emphasized the reward aspects (Reward group, N = 27), while others expressed a preference for the initiative's underlying idea, such as promoting sustainable mobility (Initiative group, N = 27). The remaining 14 participants' replies focused on other elements, such as the competition, and traveling close to nature. We sought to explore whether users' preferences had any impact on their scores in the overall score and the intrinsic motivation (IM) and extrinsic motivation (EM) constructs. First, a Mann-Whitney U test was employed to assess potential differences in the overall score between the two groups (initiative, reward). The results indicated no significant difference in the overall score between the two groups (W = 293, p-value = 0.219).

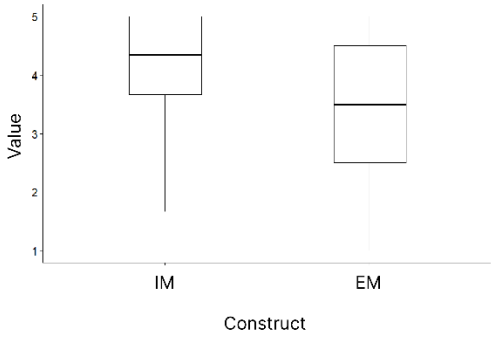

Figure 8: Participants' scores in the IM and EM.

Subsequently, a rank-transformed ANOVA was conducted (one factor between preference, 2 levels: initiative, reward; one factor within subscale, 2 levels: IM, EM). The results revealed a significant main effect for the subscale factor ($F_{1,104} = 9.792$, p-value = 0.002), while no significant main effect was observed for the preference factor ($F_{1,104} = 0.234$, p-value = 0.630). Tukey post-hoc test[7] confirmed the difference between EM and IM (IM M = 4.296, SD = 0.729; EM M = 3.454, SD = 1.381; t = -3.129, p-value = 0.0023). Additionally, no significant interaction effect was present ($F_{1,104} = 0.014$, p-value = 0.907). Finally, to answer RQ3, we conducted a 2x4 rank-transformed ANOVA to examine potential differences in overall scores based on participants' age and gender (2 between factors: age, 4 levels: "<20", "20-35", "36-50", "51-70"; gender, 2 levels: female, male). The results revealed no significant main effect for both age and gender (age: $F_{3,109} = 2.149$, p-value = 0.0982; gender: $F_{1,109} = 1.2246$, p-value = 0.271), and no significant interaction effect between the two ($F_{3,109} = 1.790$, p-value = 0.153) (Figure 9).

[7] Emmeans library

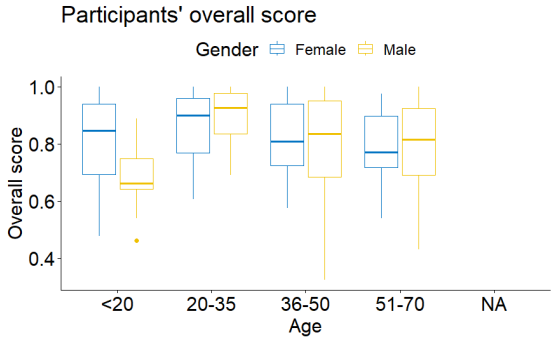

Figure 9: Participants' overall scores, divided per age and gender.

6. Discussion

The mobility campaigns involved a total of 362 participants, producing a collective 33,987 sustainable trips, for a total of 157,928 sustainable Kms, and reducing CO_2 emissions for a total of 34,8t. Analyzing the questionnaires administered at the beginning and end of the AIR-BREAK campaign, we found an increase in terms of eco-sustainability by participants. In fact, users reported significantly higher sustainability scores at the end of the campaign. Furthermore, we found that in the total number of users who completed the post campaign questionnaire, the construct of intrinsic motivation significantly outperforms that of extrinsic motivation. This indicates that (RQ1) the AIR-BREAK campaign is effective in promoting eco-sustainable behaviors and particularly incentivizing people to use more sustainable means in their daily travel. Overall, the results obtained seem to indicate a balance of the two to produce both a behavioral change and an appreciation of the application, resulting in a consequent long-term behavioral change expressed by the users and an overall appreciation of the campaign. As noted in the literature [20, 21], not necessarily the implementation of game design elements produces an effective gameful system. In analyzing participants' preferences toward the campaign elements, we identified two prevalent groups: those who showed particular interest in the rewards (virtual and otherwise) related to the campaign, and those who liked the idea related to the initiative the most (RQ2). Despite the division into the two groups, the data showed no differences in the total score, as well as indicating that in both cases IM is higher than EM. This suggests that the design of the gameful system does not make participants overly attached to rewards. Due to the lack of a main effect of the group, as well as the absence of an interaction effect between the two factors analyzed, we can not identify specific elements in the campaign that motivated users more than others in adopting sustainable mobility behaviors. In addition, we found no differences in campaign appreciation (total score) by age and gender of participants, indicating how the initiative is appreciated by different demographic groups (RQ3). As noted in the literature, it is possible that age and gender moderate the appreciation for different aspects of the gameful design [35, 34]. The absence of

differences in appreciation of the initiative's design and gamified system is an excellent finding, given that the campaign aims to raise awareness of sustainability with a broad demographic. We did find, however, how EM correlates negatively with sustainability score at the beginning of the campaign. This suggests that the presence of game elements may indeed capture the attention of those who were not particularly inclined to use environmentally sustainable means of transportation. It also suggests that they do not lead to phenomena such as the over justification effect [45, 46] in those users who were already showing high levels of sustainability instead.

6.1. Limitations

It is necessary to point out that the reported results have limitations. First of all, data in the literature report that for factor analyses, a size larger than 200 participants is recommended [47]. Furthermore, the sample size was found to be non-homogeneous between different analyses. Unfortunately, not all users responded to either the pre- or post-campaign questionnaire, leading to varying sample sizes based on the analysis conducted. Regarding pre-post analysis in campaigns, it should be noted that few users responded to the pre-campaign questionnaire, reducing the reliability of this data. Although there is data on CO_2 savings produced, behavioral change and future behavior are inferred from items and not from behavioral analysis, hence it is not possible to clearly and linearly determine whether users were moving sustainably even before the campaign.

7. Conclusions and future works

In this paper, we introduced AIR-BREAK, a project designed to promote sustainable behaviors within the general population, with a particular focus on encouraging eco-sustainable mobility practices. AIR-BREAK has exhibited considerable success in facilitating a positive shift towards more sustainable daily travel methods. The mobility campaigns developed and implemented in this project garnered significant participation, resulting in a noteworthy increase in sustainable trips, and a reduction in CO_2 emissions. The findings indicate that the gamified approach, incorporating intrinsic motivation and tool attractiveness, has proven effective in motivating individuals to embrace and maintain environmentally friendly transportation choices. The questionnaire analyses revealed an overall improvement in participants' eco-sustainability scores. Notably, the campaign's effectiveness transcends demographic characteristics such as gender and age, indicating its broad appeal and impact. It's worth mentioning that while a significant number of participants identified rewards as a positive aspect of the campaign, this did not compromise their intrinsic motivation. In summary, the AIR-BREAK project has not only successfully met its initial goals of encouraging sustainable mobility throughout the campaign but has also established the groundwork for enduring behavioral transformations. The emergence of local communities championing sustainable mobility and the highly positive feedback from participants suggest the project's potential for a more extensive societal influence. As urban centers persist in addressing the complexities of mobility, the AIR-BREAK project offers valuable lessons on the efficacy of gamified interventions in fostering environmentally conscious behaviors, opening avenues for future innovations in sustainable urban mobility initiatives.

7.1. Lesson learned

The insights gained from the AIR-BREAK campaign provide a foundation for future initiatives aiming to promote sustainable behaviors. Moving forward, the positive correlation between intrinsic motivation and sustainability scores suggests a focus on designing gamified systems that tap into users' inherent motivations. Furthermore, understanding the diverse preferences of participants — some favoring rewards while others valuing the initiative itself — indicates the potential for tailored campaign elements to engage a broader audience. To leverage these findings, future campaigns could implement adaptive gamification strategies, tailoring elements to individual preferences to maximize engagement. Additionally, considering the lack of significant differences in campaign appreciation based on age and gender, future initiatives might adopt inclusive design principles, ensuring accessibility and appeal across diverse demographic groups. Addressing limitations, future campaigns could strive for larger and more homogeneous sample sizes, employing robust methodologies for pre-post analyses. The integration of behavioral analysis alongside self-reported data could provide a more comprehensive understanding of the sustained impact of gamified interventions on participants' mobility choices.

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