

## **ABSTRACT**

MaaS, with its user-centric vision aiming at more flexible, personalized and on-demand mobility services, has a perspective to address the key sustainability challenges of the mobility of the future: transport solutions that are integrated, inclusive, and time-efficient, while containing the economic, social, and environmental costs. Civic engagement is a key success factor towards this objective: to fully embrace MaaS transformation, citizens need to feel part of the process. Gamification proved to be effective to raise citizens' awareness, encourage their participation, and promote a gradual but profound behavior change. These characteristics can be exploited by MaaS solutions to attract users and encourage the acceptance of tailored mobility plans. The chapter presents two successful cases of gamified systems aiming at promoting a more sustainable mobility, Play&Go and Kids Go Green; investigates the potential of gamified systems, in combination with MaaS solutions, in terms of citizens' engagement and behavior change and discusses current limitations and future challenges.

## **INTRODUCTION**

Within a Smart City, mobility plays a fundamental role: the way in which citizens experience the city, access its core services and participate in the city life strongly depends on its mobility organization and efficiency (Vesco, 2015). In this context, the challenge that cities are facing is very ambitious: on the one hand, administrators must guarantee to their citizens the right to mobility and to easily access local services, on the other hand they need to minimize the economic, social and environmental cost of the mobility system.

Dealing with this challenge requires a holistic approach that allows to efficiently harness existing mobility resources while integrating and promoting emerging mobility services to enable an integrated, efficient and sustainable mobility ecosystem. To this end, cities are planning and implementing interventions at the level of infrastructures, services and mobility policies.

The inadequacy of traditional transportation models is proven by the proliferation of alternative, social and grassroots initiatives aiming at a more flexible, customized and collective way of organizing transport (e.g., car pooling, ride and park sharing services, flexi-buses). Some of these attempts have become popular (e.g., Uber, BlaBlaCar, FlixBus), even though, in most cases, these are isolated solutions targeting specific mobility target groups and are not part of the city mobility eco-system, which is still mainly based on traditional public and private transport facilities.

An attempt of re-thinking the way mobility is managed and offered is represented by the Mobility as a Service (MaaS) paradigm. MaaS solutions (e.g., MaaS Global: <http://maas.global>) aim at arranging the most suitable transport solution for their customers thanks to cost effective integrated offer of different multi-modal means of transportation. MaaS also foresees radical changes in the business landscape, with a new generation of mobility operators emerging as key

actors to manage the increased flexibility and dynamism offered by this new concept of mobility. The MaaS paradigm aims at changing mobility habits by empowering the users in finding customized answers to their own specific mobility needs (Jittrapirom et al., 2017). Today, the user has to plan the route from source to destination (i.e. use Google maps), select the mobility modes (e.g. bus, train, car etc.) for the various trip legs and acquire the resources needed (reservations/tickets etc.). With MaaS, mobility will become a service: the user will get from a single mobility operator the best "all-inclusive" solution according to his preferences and to the current availability and traffic/environmental conditions; the user will buy a single ticket for the whole trip, with the mobility operator taking care of re-routing the user in real time to different modes in case of delays, changed conditions or new better traveling options.

MaaS essential characteristic is its user-centric vision, with mobility services that are flexible, personalized and on-demand. By enabling seamless multi-modal travels with accessible and affordable costs, MaaS can play a key role in shifting the interest of end-users from private car to alternative transport modes (Chowdhury and Ceder, 2016; CIVITAS, 2016; König et al., 2016). MaaS has thus the potential to contribute towards the strategic goals of Smart Cities: a more efficient, sustainable and accessible mobility (Jittrapirom et al., 2017).

Availability of real-time mobility information and interoperable inter-modal solutions (e.g., for travel planning, booking and ticketing) are certainly key ingredients offered by the MaaS paradigm; but another very important aspect of MaaS, as a socio-technical phenomenon, is users' acceptance and adoption (Giesecke et al., 2016; König et al., 2016). Innovative infrastructures, applications and services are liable to fail if they are not combined with actions aimed at making citizens aware and involved in this process and to influence their mobility habits in a gradual but profound way (Vesco, 2015).

In most cases, citizens' daily mobility choices are driven by habits and are based on wrong or outdated beliefs (Hamari et al., 2014). Citizens need to be aware of the mobility services offered by their city and of their actual value (in terms of time, cost, and environmental impact). They need to be conscious of the impact of their individual daily choices (in terms of traffic, greenhouse gas emissions and social cost). Most importantly, they need to feel part of a community that, through daily individual choices, can play a key role towards the fulfillment of city-level mobility strategic objectives. In other words, individuals and communities have to learn to take responsible actions and this can only be achieved through the development of a new culture for urban and rural mobility.

In recent years, a significant effort has been undertaken to understand how interactive technologies can be leveraged to raise citizens' awareness, encourage their active participation, break bad habits and promote behavior change towards a more sustainable lifestyle. To this extent, gamification is emerging as a persuasive technology with significant potential (Koivisto et al., 2019; Di Dio et al., 2018) and opportunities for application in the mobility domain (Hamari et al., 2014; Gabrielli et al., 2013; Holleis et al., 2012; Kazhamiakin et al., 2015; Marconi et al., 2018; Briones et al., 2018), as well as in several other domains in the environmental sustainability realm (Cowley et al., 2011; Orland et al., 2014; Shiraishi et al., 2009; Lee et al., 2013). The key idea is to leverage on the motivational and persuasive power of games by designing motivational systems that properly exploit and embed game concepts and

elements (Weiser et al., 2015; Nakamura et al., 2014) to pursue a change in the player's behavior. Gamified systems motivate people to make certain decisions or carry out certain tasks that are important in order to reach valuable objectives, even when they are somehow unattractive, by turning them into fun and rewarding experiences.

The aim of this chapter is to investigate in detail the application of gamified systems in the mobility domain and to explore the potential impact of their integration within MaaS based solutions, in terms of end-user's engagement, motivation and retention, towards the goal of a more efficient and sustainable mobility of the future.

The chapter starts with an overview of existing solutions, discussing their application context and impact. Then, in the following Sections, two particularly significant experiences that we have developed and experimented on the field for several years, are analyzed in detail: Play&Go and Kids Go Green. The former is a gamified system targeting citizens and promoting sustainable home-work mobility, the latter is a playful education system that promotes active and sustainable mobility in primary schools. In both cases, these initiatives have proven to be effective in terms of retaining participants' engagement on a long term (several months), raising their awareness, and inducing a change their mobility habits.

Play&Go is a long-running gamified urban mobility campaign promoting voluntary travel behavior change, which has been active in Trentino (Italy) since 2015 (through four yearly editions). In Play&Go players exploit a mobile app to track their sustainable journeys, which are subjected to an automatic validation procedure and are rewarded with virtual points and allows the player to proceed in the competition. Play&Go combines standard game elements (e.g., points, badges, leaderboards, real prizes) with personalized game content (i.e., weekly challenges) that is tailored to the player's profile and is specifically focused on encouraging and rewarding a positive change in the player behavior. Field trials have achieved significant results. In 2019 edition, in six months 590 players actively participated to the game and tracked 64.251 trips, of which 45.238 with zero impact (by foot or by bike), and more than 250,000 kilometers were traveled sustainably. Furthermore, 66% of players declared to have adopted more sustainable mobility habits thanks to the game and 45% experienced, thanks to the game, a new sustainable mode of transport. These experiments have shown both the ability of the approach to support citizen participation in long-term games, and the ability to break habits and change the behavior of players towards more sustainable mobility habits.

Kids Go Green involves the entire school community (children, teachers, and families) in a gameful educational journey to promote sustainable and active home-school mobility for primary and middle school age children. In Kids Go Green, the sustainable kilometers made by each child on their trips from home to school (e.g., on foot, by walking bus, by bike, with the school bus) contribute to the progress of the whole group of children on a virtual educational journey to places in the real world that is personalized according to the group interests and capabilities. Kids Go Green has been adopted for three consecutive school years in Trento and Ferrara (Italy), involving a total of 16 schools, 1844 children, and more than 100 teachers. After three years of research and development, Kids Go Green has demonstrated strong impact in terms of sustainable mobility, with increased awareness and understanding of the topic

by the children and an impressive impact on the mobility behavior lasting beyond the conclusion of the trials. This solution also proved to be effective in terms of educational value, offering innovative, interdisciplinary learning opportunities integrated into the existing academic program and the creation of a sense of community as the students are motivated by a common goal and move together virtually through the space of the interactive, educational game.

Despite the success of these experiences, there are still some key aspects that need to be investigated to fully exploit the potential of gamified motivational systems: reach also those citizens that are not particularly sensitive to sustainability issues; reward the actual behavior improvement, rather than the player's mobility performances; provide an accurate measure of the impact of the mobility campaigns. The chapter ends with a discussion on lessons learned, best practices and future challenges, that might guide researchers and practitioners in this field.

## **BACKGROUND**

The idea of using game design elements in non-game contexts (Deterding et al., 2011) to motivate and increase user activity and retention (Ryan et al. 2006; Johnson et al., 2016) has rapidly gained traction in interaction design and digital marketing. This approach, also known as gamification or gameful design, fosters motivation by employing elements and characteristic proper of entertainment games in other systems (Ryan et al. 2006; Johnson et al., 2016). The individual's personal inner motivation (Glanz, 2010; Michie et al., 2010) and intention (Fogg, 1998) guide the process of behavior change, leading to a positive influence (Hamari et al., 2014; Johnson et al., 2016). One of the key application domains are technologies that aim at persuading to assume a positive behavioral change (PBC). Designers can exploit the symbolic nature of games (Salen et al., 2004; De la Hera Conde-Pumpido, 2013) to guide the players during their experience so as to foster a behavioral change (Sicart, 2010). Moreover, the global and massive usage of smartphones, can be exploited as a tool to give immediate feedback on users behaviors by sensing and predicting how the way they act impacts the surrounding environment. Fogg (1998) defined the concept of persuasion as "an attempt to shape, reinforce or change behaviors, feelings or thoughts about an issue, object or an action". Hence, making users understand and internalize complex world events, even though being a challenging task, can be eased through simulation in games. In fact, according to the semiotic principle, meaning that users perception of signs in the system is influenced by the context in which they encounter them (Salen et al., 2004). Proceduralists share this line of thought as they assess that, due to their procedural nature, games can address serious topics (Sicart, 2010). The designers can embed meaning in the games' elements to guide players during their experiences and, more importantly, to persuade them to assume a certain behavior by making them actually experience the intended message (Sicart, 2011). In other words, games can be used as a Persuasive Technology (PT) since they can function as cognitive frames to guide the interpretation of the signs embedded in them (De la Hera Conde-Pumpido, 2013). However, despite Wright and Bogost's (2007) belief that forcing constraints contribute to the creative process, Sicart (2011) argues that proceduralism hinder players from the ability of expressing themselves. This limitation is dangerous, since the behavior change is guided by the individual's personal inner motivation (Glanz et al., 2010; Michie et al., 2011) and intention (Fogg, 1998). Another great supporter in building intrinsic motivation in performing the task in question (e.g. eating healthily or adopt sustainable mobility habits) is relatedness (Zhang, 2008). In fact, one of people's basic needs is the sense of belonging and of being in connection with other human beings (Deci et al., 2000). Gameful systems, by

building collective intentions (we-intentions), make true cooperation happen (Searle, 1990; Tuomela, 2011), which leads to a higher commitment in the activity that elicits this feeling of collectivity (Morschheuser et al., 2017).

As a consequence, using game-like systems to assist the development of a Smart City, with the common benefits that derive from it, appears to be a natural evolution. Among the many aspects that can be treated, sustainable mobility takes a big slice of the interest. In fact, there is a plethora of applications which, with a diverse extent of complexity, employ game elements. In London, the gameful system of Chromaroma (The Guardian, 2010) incentive users to visit new areas to earn virtual points and win challenges. In the city of Bogota, Colombia, gamification has been used to change people's behavior (Castellanos, 2016), by pushing them to use ecological transportation means, like walking and biking. To this purpose, both monetary and non-monetary incentives have been delivered. Game-like mechanics have also been used to discourage bad driving behaviors, for instance by Volkswagen (Volkswagen, 2011), which awarded prizes to conscientious drivers by rewarding them with money collected from hazardous drivers. Gamification can also be employed to promote a particular transportation service and hence to have an impact in terms of mobility, such as bike sharing systems - which are usually a cheap and ecological choice. An example of an attempt to foster the usage of bike sharing, despite the cold season approaching, was in Washington DC, USA, where the city started a contest with both real and virtual prizes to avoid people abandoning the service. The campaign was so successful that the rides increased by 67% in two months (Capital.com, 2011).

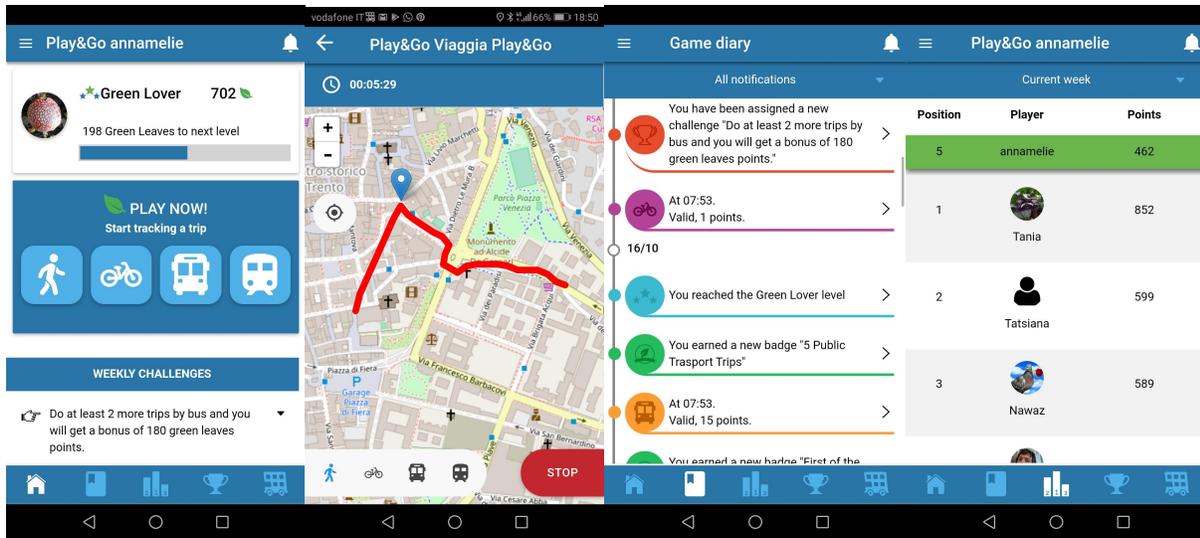
However, setting up an incentive policy to push certain behaviors is challenging. This is particularly true when behavior-based rewards are introduced since they may function only in the short-term. All the above-mentioned systems rely on the willingness to move ecologically. If the users are reluctant to abandon the car some other strategies should be employed. An alternative is eco-driving, which is a way of driving with the purpose of reducing CO<sub>2</sub> emissions, which could be extremely beneficial for the environment (Barkenbus, 2010); in the literature there are already some examples of the usage of game elements in this context (Froehlich, 2015). Metropia (Metropia, 2017) is a mobile platform that assists users in finding alternative to their travels, to give an optimized solution. This is achieved by predicting the traffic exploiting real-time data. Drivers are rewarded if they shift their journey in less busy timeframes, and the reward strategy is informed by behavioral economics strategies and gamification elements. The positive aspects also involve environmental benefits in terms of CO<sub>2</sub> emissions. On the side of academic experiments, there is “Spitsmijden” or “traffic avoidance” (Knockaert et al., 2012), which took place in The Netherlands in 2006. The aim was to encourage users to avoid traveling in the peak hours through virtual points, which could be used to obtain a smartphone. Despite having impressive initial results, the main drawback was that once the incentives were revoked, the mobility habits returned as those pre-intervention. This is mostly due to the nature of the gameful strategy employed, heavily relying on physical prizes. However, this does not stimulate players to choose other means of transport instead of personal transportation. Carpooling is a system through which users with similar routes can use one car. Its main goal is to match people who commute to work. Olszewski et al. (2018) propose a variation of urban game in the form of a serious game to help to significantly reduce the number of cars in Warsaw. Another example of gamification implemented by the transport administration is described by Shreenath et al. (2015). They conducted a feasibility study for the implementation of gamification within Trafikverket

(the Swedish transport administration), by augmenting with game elements the existing processes. They came up with guidelines on how and when gamification should be applied. UbiFit (Consolvo, 2007) is a mobile app that gives users feedback on the level of "greenness" of their transportation behaviors by sensing their actions through both the smartphones and wearable devices, and self-declarations (Choudhury et al., 2008). The feedback is in the form of an abstract visualization. This visualization exploited the psychological theory that employing animals is helpful in fostering a connection between humans and nature (Myers et al., 2002). Moreover, adopting a green behavior resulted in positive rewards - earning points. UbiFit's focus was on making users aware of their habits and of the impact that their actions have on the environment. Another example of a mobile system employing game-like mechanics to promote an ecologic mobility behavior is Bella Mossa, a game active in the city of Bologna (Italy). The game awards physical and virtual prizes to citizens that track their journeys through the app, by giving a higher importance to the more sustainable means. However, "we are at the Atari 2600 stage of persuasive technology and gamification" (Froehlich, 2015) and still plenty of studies have to be held so as to understand how to exploit its true potential.

### **PLAY&GO: AN URBAN MOBILITY GAME**

Play&Go (Figure 1a) is a mobile app fostering a positive behavioral change, built upon the framework of Kazhamiakin et al. (2016). Players are involved in a gameful environment in which they can track their daily journeys (Figure 1b) and get points for undertaking a green behavior. This initiative was born in 2016 from a partnership of Fondazione Bruno Kessler and the Municipality of Trento (Italy), whose purpose was and is to move towards a green and smart city. Every year, the Municipality set a 6-month game, structured in weeks, in which also physical prizes are put out for grabs. Examples of prizes are public transit passes, museum or event tickets, or fitness classes. Since the first release of the game, which is currently in its 4th edition, the dialog among the three main stakeholders - designers, municipality and citizens - has contributed to significantly improve the system.

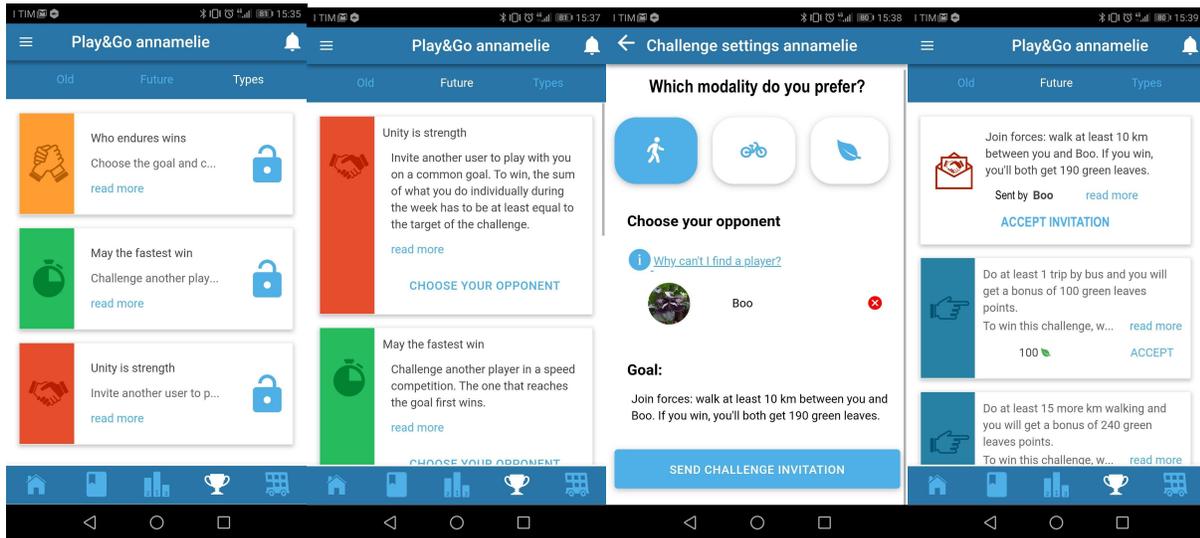
The core mechanic of the game is that players can track their movement through the app by specifying whether they are walking, riding a bike or using public transportation (bus or train). At the end of the travel, they receive an amount of Green Leaves points proportional to the number of kilometers travelled and the level of sustainability of the means employed (e.g., walking confers more points than using the bus). However, before having awarded any point, the trip is subjected to a semi-automatic validation process, which assess the veracity of the declaration. For example, when a player registers a bus trip, the system looks for matches between the bus timetable, and the time and geo-localization of the tracked trip. Players can also review the actions they performed in their *Diary* (Figure 1c).



(a) Homepage (b) Tracking a trip (c) Diary of actions (d) Leaderboard

Figure 1. Play&Go Screenshots

The gameplay has a weekly structure so as to have weekly leaderboards, which can be used to assign the weekly prizes offered by local sponsors. Moreover, weekly leaderboards (Figure 1d), that consider the performance achieved in a small window of time, allow newcomers to have a fair opportunity to compete with veterans in the game. The seniority of players is represented by a level associated to their profile. The level (e.g., Green Soldier, Green Warrior, Green Guru) is calculated in function of the total amount of points gathered and is a measure of the players' experience.



(a) Unlockable content (b) Multiplayer Challenges (c) Send an invite (d) Accept an invite

Figure 2. Play&Go - Multiplayer game elements

In the game particular attention is paid to keep users in a state of flow. To this extent, players are motivated to improve (or maintain) their performance through weekly challenges, with care to

not frustrate them with unreachable targets. Challenges are generated by a Recommender System (RS) so to be tailored to each user, considering player history, preferences and skills. The rewards for such challenges are computed in function of the estimated difficulty for the challenge considered the player in terms of the effort she is forecasted to make to win it. Example of an individual challenge is the following: “Do at least 3 kilometers by bike to win 120 Green Leaves points”.

In Play&Go multiplayer challenges are also available (Figure 2), so as to allow players to build a sense of relatedness and community by engaging in a sustainable behavior. The multiplayer challenges always involve two players and can be one of the following kinds: cooperative, time-based competitive and performance-based competitive. Both the target and the reward are automatically calculated by the system, according to the history and preferences of the two players involved in the challenge. The target is always the same for the two players, while the reward may differ due to the estimated difficulty for each player. In the cooperative mode, the target is cumulative, and players have to work together to reach it, before the challenge expires. The individual contribution is not important and, in case of win, they both receive the same prize. An example of cooperative challenge is: "Join forces: bike at least 10 km between you and Player 2. If you win, you'll both get 120 green leaves". The other two multiplayer challenge modes are both competitive, but the mechanic is slightly different. In the time-based competitive mode, there is a fixed target and the winner is the player that is fastest in reaching it. The target is calculated to be achievable for both players, without being too easy to reach. It could happen that players have different experience level, and hence for one of them the effort to employ is higher. Therefore, the reward for the two players may be different, since it is proportional to the level of difficulty calculated for each party: - i.e., the strongest players would get a lower reward than the weakest. An example of such a challenge is: "Bike 4 km before your opponent Player 2. If you win, you'll get 100 green leaves. If Player 2 wins, she-he will get 150 green leaves". The last competitive mode is the performance-based competitive challenges. This time there is no target, but the challenge will be active for the whole week. Upon expiration, the player that has the highest performance wins. To avoid players setting for a low performance, the reward is a booster calculated on the weekly points obtained - e.g., "Walk more km than your opponent Player 2. The winner will get a 40% bonus of all the points got during the week".

Since the game not only implements the “blue-print triad” – e.g., points, badges and leaderboards – but also more articulated game elements, some of the features are made available to players later on in the gameplay. In other words, unlockable content is associated to the reaching of every level.

**Level 1** - players receive their first customized individual challenge.

**Level 2** - players can choose one among two customized individual challenges.

**Level 3** - players can choose one among three customized individual challenges.

**Level 4** - players can unlock one among the three modes of multiplayer challenges available (Figure 2a) - cooperative, time-based competitive and performance-based competitive challenges. From this point onward, they can invite other players to a multiplayer challenge (Figure 2b).

**Level 5 and 6** - players can unlock another multiplayer challenge mode.

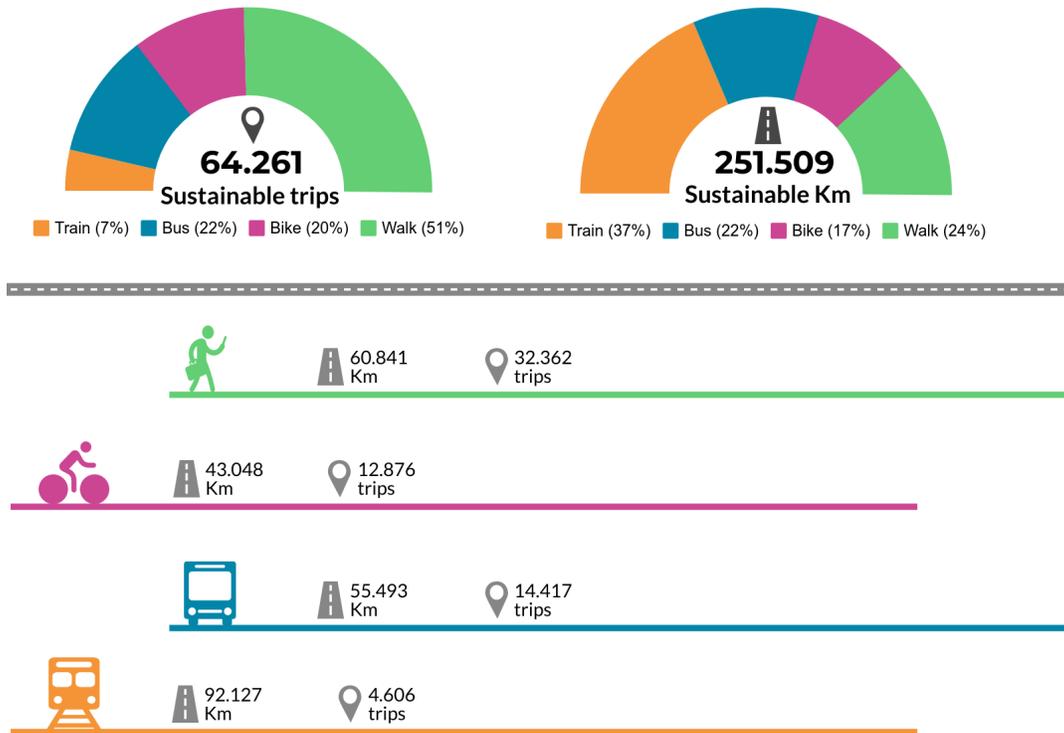
In conclusion, the more players advance in the game, the vaster are their possible choices. It must be noticed that each week, players can only have one active challenge, no matter whether it is single player or multiplayer.

At the beginning of every week, players have a small window of time (a couple of days) when they can program the challenge for the following week. Programming a challenge means selecting whether they want to engage in an individual challenge (and choose one, if they are at least at level 2) or they want to engage in a multiplayer challenge. To engage in a multiplayer challenge, players have to reach at least level 4. At that point, they can unlock one multiplayer mode. To initiate a multiplayer challenge, players can select one of the modes that they have unlocked and, then, invite another user. Prior to the invitation, the initiator of the challenge must specify the type of challenge they want to activate (Figure 2c), and hence choose among bike, walk or a general challenge on the amount of Green Leaves points obtained. The RS will calculate the best target depending on the two players involved and the mode selected and, then, will generate the appropriate reward(s). During this step the more competitive players could actuate a strategy, meaning that they could play with the invitation parameters – i.e., challenge mode and opponent – so as to have the best chances to win or the highest reward. Players can make only one request at a time. Once an invite has been sent, the player who sent the invite can still cancel the request to make another one, while the invited player can either accept it or reject it (Figure 2d). When the invite has been accepted, the players involved cannot make other invitations and/or accept other challenges until the following week.

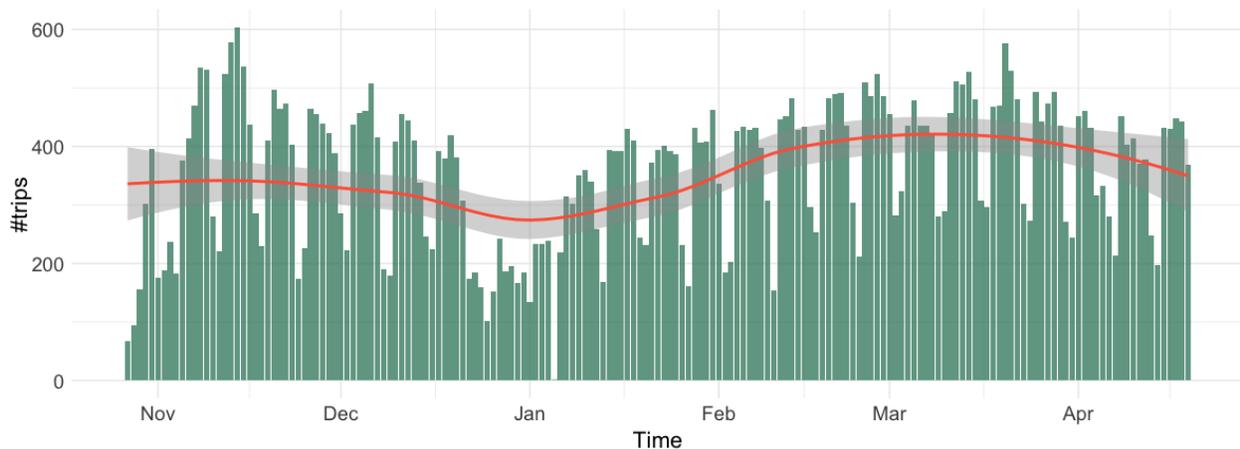
Every gamification campaign has been followed by the analysis of the data retrieved throughout the six-month period. We exploited two kinds of data sources which helped in conducting both quantitative and qualitative studies. The first and most prolific data source is gameplay logs, in which we stored every in-game action of the players, examples being the trips tracked, information on the challenges received and the points gained. The second kind of data source are surveys. We submitted players an initial survey, to collect information on their preference and personality; a survey inspecting players response to the multiplayer challenges; and a final survey inquiring players about their game experience. The main difference between the two data sources lies in the amount of data obtained, in that, on the one hand, we have logs for all players, while, on the other hand, not every user answered to every (or any) questionnaire. In particular, we had 480 respondents for the initial survey, 81 respondents for the questionnaire about the multiplayer challenges, and 87 respondents for the final survey. The insight gained during such analysis have and will lead the design of further versions of the game.

In our most recent edition of the game, which run from the end of October 2018 to April 2019, we observed a more committed audience of players. In comparison to the previous edition, where the amount of time spent in the game were more modest despite having a higher rate of registered players, we found that the active users were fewer but more constant in the usage. In fact, while on 2017-2018 edition we counted 1079 registered players (of which 747 were active), this year we had 834 registered players (590 active). By active players we mean players that tracked at least one trip in the game. It follows that the rate of active players among the registered ones increased. Moreover, even though the active players were slightly less in this year edition we found an increase in the total amount of kilometers (and trips) tracked – i.e., from about 53k trips to about 64k trip and from about 240k kilometers to 250k kilometers (Figure 3). Of those trips, the vast majority were tracked by foot, followed by train, bus and bike.

Therefore, the transportation means we call “zero impact” (i.e., by foot or by bike) were the favored ones. This result should be interpreted considering also the background of players, in terms of preferred transportation means used. The majority of our users (35%) declared to mostly use public transportation means, while the remaining selected as primary means car, walk and bike (25%, 21% and 18% respectively). Therefore, the 75% of our users already moved in a green way, with 39% of them assuming a “zero impact” behavior. Despite this, the achievements are still impressive, considering that before the game 48% of our players declared to use the car about 3 times per day. Moreover, 66% of our users declared to have changed their mobility behavior, thanks to the app, to a medium-to-high extent.

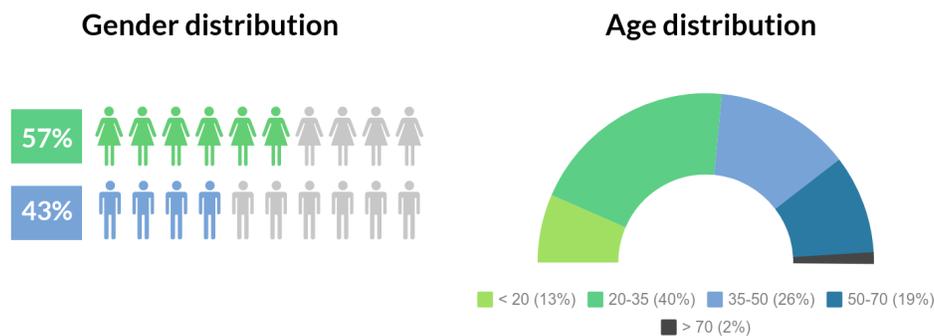


**Figure 3.** Amount of trips and kilometers travelled, divided by transportation means, in Play&Go, October 2018 - April 2019.



**Figure 4.** Distribution of the number of tracked trips over time in Play&Go, October 2018 - April 2019.

Players participation and effort can also be measured through the outcomes of the challenges. Among the 5.9k challenges assigned, players won half of them. Players were also well disposed to contribute to our understanding of their experience by answering to in-game surveys: 483 of them answered to the initial survey and 86 to the final survey. On the overall, player experience was rated positively: 85% of users gave a rate higher than 4, with the scale going from 1 to 6 and 6 representing the best experience. The game also had an impact in terms of mobility, since a fair number of users (40%) tried a new means of transportation, which was public transportation for half of them. It is also interesting to notice that we did not observe drastic low peak in the participation rate, in spite of holidays and bad weather (Figure 4), apart from a lower participation that has been registered during Christmas holidays (December 22, 2018 to January 6, 2019).



**Figure 5.** Gender and age distribution in Play&Go, October 2018 - April 2019.

In terms of demographic, we observed that our players are quite heterogeneous (Figure 5) in terms of gender (57% female), which is probably due to the variety of game elements and mechanics implemented. Moreover, the distribution of the age range follows the shape of a gaussian curve slightly skewed towards the lowest extreme: 13% of our users are younger than 20 years old, 40% are between 20 and 35 years old, 25% are between 35 and 50 years old, 19% are between 50 and 70 years old and 2% are older than 70. This age range distribution is in-line with similar initiatives: all the age range are well represented, exception made for the younger users (less than 20 years old, 13%) and the elderly users (more than 70 years old, 2%). The participation of younger users is limited by the age restrictions imposed by the national regulation for prize-based competitions (players younger than 16 cannot register). The low rate of players over 70 years old can be related to elderlies' general resistance to smartphone applications: even when owning a smartphone, elderlies mainly exploit its basic functionalities (e.g., calls and messages).

## **KIDS GO GREEN: GAMEFUL EDUCATION FOR SUSTAINABLE MOBILITY**

Being an independent and active road user is fundamental for the physical, social, cognitive and emotional development of children and adolescents (Beunderman, 2010; Brown et al., 2008;

Kolotkin et al., 2001). Nevertheless, in recent decades there has been an increase in the number of parents placing restrictions on - and thereby limiting - the active mobility of their children (Björklid, 2002; O'Brien et al., 2000; Hillman et al., 1990; Hillman, 1993; Rissotto and Tonucci, 2002) and the expression "back-seat generation" is sadly becoming well known in international debates (Child Friendly Cities Initiative, 1996; Child in the City Foundation, 2002). The reasons why parents choose to drive their children to school vary. For some cases it is due to lack of traffic safety measures for children as pedestrians or cyclists. For others it is related to practical considerations (Fotel and Thomsen, 2004; SKL, 2012), convenience and time saving (McDonald and Aalborg, 2009), since driving the children to school makes it easier to manage the daily family juggle.

Considering that children's mobility accounts for approximately 20% of the total daily travelling population in the EU (European Commission, 2002) and that chauffeuring children accounts for a large proportion of cars on the road, the impact of this ever growing phenomena is huge in terms of traffic, safety and pollution in our cities.

Plenty of grassroots and participatory initiatives are being launched at a local level providing bottom-up solutions supporting children's sustainable and active mobility (e.g., walking buses, children bike-trains, volunteers at crosswalks). However, most of these initiatives struggle to scale up and often do not survive long after their bootstrapping. This is mainly due to their fragmentation and isolation, lack of reliability, convenience and flexibility of the offered mobility services, especially if compared to the use of private cars, but also due to the lack of awareness and difficulty in breaking away from bad habits.

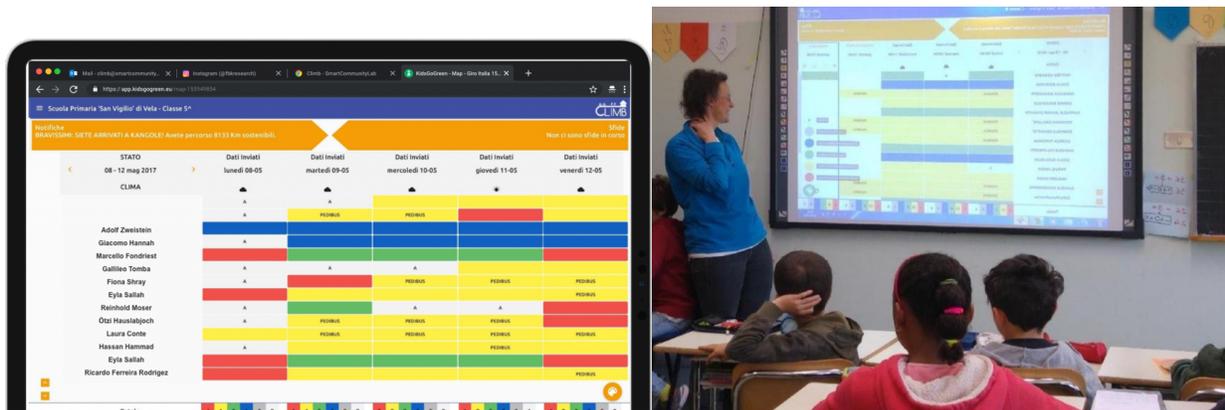
Education is our best hope and most effective means to cope with environmental sustainability challenges, since it can empower a new generation of citizens with values, knowledge and skills to critically reflect, make informed decisions and act in a sustainable way. Childhood is a privileged time for environmental education: it creates a new attitude of care, respect and sustainable life habits and establishes a reinforcement loop spreading the educational impact to their families and the communities they live in. Children are the citizens of the future and will bring their habits into adulthood, thus shaping our future cities.

Kids Go Green (Marconi et al, 2018; Kids Go Green Website, 2016) aims at changing the attitude of children, their families and their community towards environmental sustainability challenges, by making the adoption of eco-friendly mobility habits a fun and social experience. Kids Go Green aims at reducing GHG emissions by inducing a collective modal shift from cars to clean sustainable mobility (walking, biking, public transport) in home-school trips for primary and secondary school pupils.

To this extent, Kids Go Green involves the entire school community (children, teachers, and families) in a gameful educational activity where the sustainable kilometers made by each child on their daily trips from home to school contribute to the progress of the whole group of children on a virtual educational journey to places in the real world. Stops along the way allow the discovery of cities, countries, and places, conveying the value of the collective sustainable kilometers travelled to date. The route, the final destination and the stops of the virtual journey are customized according to the interests and the educational needs of the teachers and can cover interdisciplinary subjects (e.g., a trip around Europe discovering culture, natural landscapes, history and architecture) or target a specific topic of interest (e.g., Italian National Parks, the journey of Ulysses, a journey discovering children's countries of origin). Teachers associate to

each stop multimedia educational material such as videos pictures, documents or web-links. Stops are unlocked when a sufficient number of sustainable kilometers is reached by the entire class, and thus can be exploited for in-class learning and for motivating children towards sustainable mobility transportation. The game is supported by a platform that captures the sustainable kilometers of each child, managing progress in the game and, through a Web App, displaying the achievements on an interactive map.

Before launching the game in the school, a set of preparatory activities is performed in order to design and calibrate the virtual journey to the needs and objectives of the participants. Teachers, involving the students and their families, collect information about current home-school mobility habits (i.e., how many children walk and cycle to school, how many are taking the schoolbus, how many are chauffeured by car) and define behavior change objectives (i.e., number of children that might adopt for more sustainable habits and modal shift). Starting from predefined ranges, a constant value is associated to each transport modality (e.g., 400 meters for walk trips, 1.000 meters for school bus trips). From these information (transport habits, behavior change targets, transport distances) the daily distance travelled by the group is calculated and the design and calibration of the journey can start. This is a co-creation activity that mediates didactical interests and needs (in terms of educational content, intermediate stops and final destination to be reached), distances to be covered by the group and the duration of the game (typically from 2 months to the whole school year). Then, the teacher associates multimedia educational material (e.g. pictures, video, web-links, documents) to each stop. Teachers exploit the Kids Go Green Web-based management application that allows them to upload their own educational content, search material from predefined online educational sources, or reuse geo-referenced educational content previously uploaded by other members of the Kids Go Green community.



**Figure 6.** Kids Go Green Web App: Daily Mobility Journal.

During game execution, every day each class exploits the Kids Go Green Web application and fill out the Mobility Journal (see Figure 6). Through a color code, each child indicates the way she reached the school on that day. Supported transport mode are walking, cycling, by school bus or public transport, by foot from a parking lot in proximity of the school (identified by teachers and families during the game set-up), or by car. The number of kilometers traveled in a sustainable way by the group (calculated on previously defined constant values in meters) in their daily trips to school contributes to the progress on the virtual journey. Classes also indicate

the daily weather and, in case of rain or snow, trips by foot and by bike are incentivized through bonus meters rewards. Classes can also enter their walking field trips done as part of the school activities.

Kids Go Green also supports for various class-level and team-level challenges: the group, upon completion of a specific achievement (e.g., zero impact day, no-car week), benefit from virtual prizes that can be exploited to cover long distances (e.g., a cruise ticket along a river, a train ticket, a hot-air balloon ticket to reach an oversea stop) or to speed up games (and promote a change in mobility habits) where the group is proceeding slower than planned.



**Figure 7.** Kids Go Green Web App: Interactive Digital Map.

Children can see their journey progress through an Interactive Digital Map (see Figure 7), usually displayed in class on an interactive whiteboard or large display. Participants can inspect their current position and the reached stops. Upon arrival to a stop, all the associated educational material is unlocked and can be exploited for in-class lessons (see Figure 8). The Interactive Digital Map is publicly accessible: in this way, children can share the progress with their families and can enjoy and benefit from the educational material also from home.



2016-2017 school year, the S. Vigilio school in Trento (Italy), experimented with the first version of the system, developing a virtual path from Trento (Italy) to Kangole (Uganda). In just four months 87 children traveled more than 8800 sustainable kilometers, crossing all of Italy and passing through Greece, Egypt and other countries of the African continent.

The data collected for the evaluation included: the Kids Go Green game logs, depth-interviews with teachers (n=3), as well as two questionnaires for the families (n=87 for both surveys). During these three months, the children took 4400 home-school trips and only 31 were by car. The impact was impressive, teachers confirmed that cars disappeared from the school surroundings and a post experiment evaluation, carried out six months after the game end through a survey administered to families (n=85), revealed that 86% of the children maintained the adopted sustainable habits.

The success of this first experimentation and the enthusiasm of children, parents and teachers enabled 10 Kids Go Green games to be activated in six schools in Trento during the 2017-2018 school year, for a total of over 600 children and 100 teachers involved. During school year 2018-2019, 25 games have been activated in 18 schools in various Italian cities, for a total of 1189 children.

These experiments have shown an impact on home-school mobility that has exceeded all expectations: during the experiments run in 2017-2018 children have traveled more than 20,000 sustainable kms; and of the 26,000 home-school trips, only 5.9% were done by car. Applied solutions proved to be effective not only in ideal settings (e.g., in schools with small communities in safe suburbs), where percentages of car-trips was almost null (0.3 – 0.6% of total trips), but also in schools located in the city center, where the maximum percentage of car trips was 15.6% (from an initial baseline of 40-50% over the total number of home-school trips). Similarly to the previous school year, the evaluation was based on the Kids Go Green game logs, depth-interviews with teachers (n=13), as well as pre and post surveys for the families (n=436).

Opinions collected from questionnaires with parents show a positive environmental effect in terms of children's and families' behavioral change as well as the educational value of Kids Go Green. For 42% of the participants, Kids Go Green had a positive impact on the way children reached school and for 26% the game changed their mobility habits also during free time and family trips, highlight that sustainable behavior was also generalized to other contexts.

Although not being a primary objective of the proposed solution, Kids Go Green resulted to have a significant value also in terms of didactics. Teachers report that Kids Go Green is an innovative educational tool that, through the principles of gameful education, promotes the definition of interdisciplinary, inclusive and participatory educational paths. Interdisciplinary, because it enables the co-creation of personalized thematic paths that integrate topics from different disciplines into a choral narration. Inclusive, because thanks to the multimedia material associated with the stops, it allows to exploit various communication channels (images, drawings, videos, websites and material produced by students and families) that offer children a varied learning experience. Participatory, since it provides for an active collaboration of teachers, students, families, educators and researchers, both in the co-creation of educational paths, and during the execution of the game which, through cooperative mechanisms, promotes a collective commitment and a concrete alliance.

Kids Go Green supports and sustains over time, through technology, the sustainable and active mobility of children, together with their peers, making them fun, participatory and safe. The game is well integrated into the educational path, nourishing and supporting the project over time, avoiding the loss of motivation. Thanks to its simplicity and immediacy, the Kids Go Green game has demonstrated a high impact in terms of didactic and socio-educational terms, significantly affecting the participation and the involvement of pupils and families in solving the problems related to traffic, pollution and safety in proximity of schools.

## **BEST PRACTICES, LESSONS LEARNED AND FUTURE CHALLENGES**

As it clearly emerges from the presented case studies, game-based motivational systems can play a key role for promoting the engagement of citizens' and transform them into active players for addressing mobility-related sustainability challenges. Gamified systems can be exploited to engage end-users and retain them on the long-term. Gamified systems are also an effective means to support reflection on the impact of citizens' current mobility choices, in that they can be exploited to encourage a break of bad habits and to discover and appreciate more sustainable, efficient, or newly introduced mobility services. If carefully designed, they can induce a gradual, but profound and long-lasting change in citizens' mobility habits.

These characteristics of gamified systems can become key ingredients of MaaS solutions. Within the MaaS paradigm, gamification and game-based motivational systems could be seen as a new layer specifically targeting end-user's engagement, motivation and retention.

Gamified sustainable mobility campaigns could be exploited to launch MaaS-based applications, attracting new users and creating an active and committed community of customers. Game-based elements could be easily integrated in MaaS solutions to promote, among all available integrated and tailored mobility options, those that are more efficient and sustainable, or to advertise newly integrated mobility services and to increase their chance of being tried and appreciated by customers. Through a combination of virtual and real incentives, game-based systems could also be exploited to retain MaaS application customers, especially for what concerns booking and payment services.

In the following, we discuss the lessons learned, current limitations and recommendations for the design and operation of gamified motivational systems in the mobility domain, as emerged from the presented case studies.

Unfortunately, it is difficult to design a fun and entertaining environment, especially when it is tied up to a "serious" application domain, such as positive behavioral change. Retaining players on the long-term (several months) is particularly important within games with a purpose, since sustainable behaviors induced by the game need to be reinforced long enough to become durable mobility habits. To this extent, following the design principles of persuasive technologies (Fogg, 2003), personalization and dynamicity are key features of an effective gamified system. The dynamicity of game mechanics (such as personalized challenges and missions, or level-based unlock of game features and virtual resources) avoids player's boredom and supports retention. Personalization is a key feature that allows to tune game objectives and goals to the player's profile and performances, promoting and rewarding behaviors that are in-line with the game

ulterior motive and that are challenging but feasible for the player (thus avoiding player's frustration).

In both our case studies, personalized, dynamic content has been the most appreciated motivational affordance by end-users. In Play&Go, weekly challenges have been the most enjoyed feature throughout the four yearly editions. In Kids Go Green, the personalization of the virtual journey, that can be designed according to the interests and didactical objectives of the group of pupils, has been the distinguishing factor for the retainment of children and teachers. Moreover, requiring a gradual feasible behavior change to players has proven to be successful both in Play&Go and in Kids Go Green initiatives. This has been achieved in Play&Go through weekly personalized challenges that required players to have a small, but incremental and continuous improvement. In Kids Go Green, one of the winning strategies has been the identification of a parking place in proximity of the school (distance from 300 to 500 meters) that parents could reach by car and from which children could walk to school (either accompanied by adults or in small groups, dependently on the child age and autonomy).

The capability to identify and block cheaters (or killers - disruptors in taxonomies of player types) is another fundamental factor to tackle in gamification campaigns. This allows to establish a sense of trust among all players, who are strongly demotivated when witnessing unfair rewards. The accuracy of the automatic trip validation algorithms in Play&Go has been a key success factor of this initiative. In Kids Go Green, this problem is widely limited by the application context, where informal social control prevents children from cheating (i.e., teachers and children, as a group, know how each kid reached the school).

Another success factor of any sustainable mobility campaign is community building. Making citizens an integral part of the innovation process and building a sense of relatedness with the rest of the community is what truly fosters motivation to use the system, and thus, to pursue a positive behavior change. This is particularly relevant for those citizens that are sensitive to sustainability issues and whose motivation can be leveraged to spread the campaign's impact and reach thousands of users (e.g., in Play&Go, 44% of participants have come to know the initiative through their friends). In the presented case studies this has been achieved through a continuous dialogue with end-users and a participatory co-design approach. End-users (citizens, teachers, children and their parents) through the years, thanks to their feedback and suggestions, had a prominent role in the enhancement of Play&Go and Kids Go Green solutions. This is a win-win situation, since organizers can gain valuable insights on the current strengths and limitations of their solution, while end-users strongly appreciate that their suggestions are appreciated and implemented.

Despite the proven benefits, there are still some limitations that emerged from the presented case studies, which constitute future challenges for practitioners and researchers in the field.

The first challenge concerns the capability of gamified motivational systems of rewarding the actual behavior improvement, rather than the participant performances. In Play&Go, this has been partially achieved through weekly challenges, which provide a reward to those players achieving the challenge goal. Nevertheless, bonuses gained when a challenge is won contribute only to a limited part of the virtual points (Green Leaves) that define leaderboards, and thus, to

the assignment of real prizes. A considerable amount of virtual points is gained by players proportionally to the kilometers traveled during each game week and to the sustainability of the used transport means. As a consequence, despite in-game daily and weekly limitations to the number of trips and kilometers that can be tracked, top players in the game were mostly citizens traveling long distances by foot or by bike, independently from the induced change by the game in their mobility habits. This aspect, related to a well-known limitation of competitive games exploiting leaderboards as a motivational affordance (Hamari et al., 2014), can result in a demotivation of all those players that are committed to the game objectives but cannot sustain top players' performances.

Another limitation concerns the capability of accurately measuring the impact, in terms of behavior change, of gamification campaigns. The main challenge in this case is related to the possibility of obtaining a baseline. In Play&Go, as in most similar initiatives, the pre-game behavior is obtained through players' self-assessment (i.e., through in-game surveys), where players declare the number of kilometers traveled per day and the main transport mode. A more reliable strategy for obtaining a precise baseline, might be to track all participants trips within a limited timeframe at the beginning of the game (i.e. one week, exploiting automatic functionalities embedded in the mobile App). However, this solution presents several drawbacks in terms of mobile phone battery consumption and end-user privacy protection and might thus result in a low acceptance from players, especially within the initial phase of the game, that is already the most critical phase in terms of churn rate. Kids Go Green does not suffer from this issue: children report all their daily trips, independently from the transport mode, from the very beginning of the game. The collected data, together with the information about mobility habits and game objectives defined by teachers and families, allow to have an accurate measure of the change induced by the game.

Last but not least, a well-known and ambitious challenge of sustainable mobility campaigns (and motivational - behavior change systems in general) is to reach those end-users that are not sensitive to the targeted issue or are particularly resistant to changes (i.e., inveterate drivers, in the mobility domain). This is a current limitation of Play&Go, where, based on the registration survey, only 25% of registered players declared to use the car as main transport mode. Kids Go Green, however, proved to be a successful case, also with respect to this challenging and widely unresolved issue. Kids Go Green is an activity that is integrated within the school programme and thus all families are involved in the game, independently from their sensitivity to environmental sustainability issues and from their practical (and in most cases understandable) resistance against adopting more sustainable mobility habits. Being a cooperative game, where the group wins only if there is a collective change in terms of mobility behavior, peer pressure is particularly effective in Kids Go Green, where children play a prominent role in convincing their schoolmates in breaking bad habits. Moreover, parents are proven to be particularly sensitive to their children's request for a change (Damerell et al., 2013). And thus, within this setting, behavior change naturally spreads through children's peers and up to their families. These characteristics of Kids Go Green, that proved to be able to tackle a major challenge of gamified systems, can inspire the design of future campaigns that are pursuing similar objectives.

## **CONCLUSION**

Game-based motivational affordances can be successfully exploited for civic engagement and to develop a new culture for urban mobility. Through a combination of game elements, virtual and real incentives, gamified systems have proven to be effective in promoting an active participation, breaking bad habits and inducing long-lasting changes in citizens' mobility habits. These characteristics of gamified systems can be exploited by MaaS solutions to attract new users, retain them on a long-term, and encourage the acceptance of tailored mobility plans suggested by MaaS-based applications. MaaS systems, offering innovative, tailored and convenient mobile solutions to citizens, combined with the motivational and persuasive power of game-based systems, have a perspective to address the key sustainability challenges of the mobility of the future and to achieve the goal of substituting private vehicles with alternative transport models.

Two application cases, targeting home-work and home-school mobility, applied for several consecutive years and involving thousands of citizens, are presented in detail. The key success factors of these case studies are analyzed, and best practices are derived to guide the design and development of similar initiatives.

Despite the proven benefits, in terms of engagement and behavior change, the investigated case studies still suffer from some limitations: being able of rewarding the actual behavior improvement, rather than personal mobility performances; providing an accurate measure of the impact of the sustainable mobility campaigns; engaging citizens' that are not sensitive to the theme, such as inveterate drivers. These constitute important challenges to be addressed in the future by practitioners and researchers in the field.

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## KEY TERMS AND DEFINITIONS

**Gamification:** The employment of game-like elements in contexts other than games, generally, to pursue a certain goal - e.g., a positive behavioral change.

**Game Elements:** These are the atoms of games, and build the foundations of the game itself. Examples of game elements are points, badges, challenges and leaderboards.

**Game Mechanics:** This term refers to the ensemble of rules that regulates players activities, and that define the allowed actions. Game mechanics are built over game elements.

**Persuasive Technology:** The technology designed with the underlying motive of modifying a certain attitude of behavior, exploiting psychological and sociological theories, such as persuasion and social influence.

**Participation:** This is a measure to evaluate the response of users (or players) to the system in question. By analyzing the intensity and the commitment of participants, a hint on the goodness of the system's design can be grasped.

**Smart City:** An urban environment that employs technology with the main motive of enhancing citizens' quality of life. It widely employs sensors to gather and analyze data, to handle the city's resources efficiently.

**Sustainable Mobility:** Moving in a sustainable way refers to the choice of preferring ecological transportation means - e.g., walking or biking - and public transportation to reduce CO2 emissions.