Towards an Applied Gamification Model for Tracking, Managing, & Encouraging Sustainable Travel Behaviours

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Abstract In this paper we introduce a gamification model for encouraging sustainable multi-modal urban travel in modern European cities. Our aim is to provide a mechanism that encourages users to reflect on their current travel behaviours and to engage in more environmentally friendly activities that lead to the formation of sustainable, long-term travel behaviours. To achieve this our users track their own behaviours, set goals, manage their progress towards those goals, and respond to challenges. Our approach uses a point accumulation and level achievement metaphor to abstract from the underlying specifics of individual behaviours and goals to allow an

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extensible and flexible platform for behaviour management. We present our model within the context of the SUPERHUB project and platform.

1 Introduction

In the SUPERHUB project we integrate multi-modal travel planning, journey resourcing and ticket purchasing with behaviour change mechanisms that encourage our users to not only find sustainable transportation options in their city but to use them also [2].

Our goal is to support our users in the formation of sustainable, long-term behaviours that are commensurate with solutions to problems in the domain of environmentally friendly travel. For example, weaning committed car drivers away from their heavy use of cars in the city center and encouraging them to use either individually sustainable travel modes such as bicycles or more sustainable mass transit modes such as buses and trams.

We achieve this by building a game-based model which gamifies the normal interactions and tasks related to sustainable travel behaviours. Gamification extends the core functionality of SUPERHUB, which is built around a capable multi-modal journey planner supplemented by personalisation features, behaviour change mechanisms [3] and strategies for managing user behaviour [4].

In the remainder of this paper we present and discuss our Points Accumulation Gamification Model (PAG-M), explore how this model is applied to the challenges presented by the SUPERHUB project and demonstrate a specific application within the sustainable transport domain using the SUPERHUB platform as an exemplar. Subsequently, we discuss some challenges associated with this approach such as bootstrapping the system to a sustainable level of functionality and managing behaviour change in the longer term. Finally we draw some conclusions and indicate some directions in which the current work will develop.

2 Background

Gamification is the application of game-oriented design approaches and or game-inspired mechanics to otherwise non-game contexts. For example, taking familiar elements from games, such as points scoring as a method for measuring achievement, and applying it in a context that would not normally be associated with play, such as travelling sustainably within an urban environment. There are two core approaches to gamifying an interaction; the first is to metrify existing tasks and the other is to modify existing tasks with additional game-mechanics or elements of play.

Metrifying existing tasks involves incorporating a measure of attainment upon which a concept of goal directed movement is predicated. Metrics are allocated to standard, existing tasks within the problem domain which are then associated with values whose accumulation leads to either reward or sanction for either the user or some related set of the users social graph, as a result of their performance in relation to to the metrics. In this approach the domain task remains the same but is supplemented with gamified metrics that enable the user to gain feedback about their performance and achievements. This approach can also be made social by enabling users to compare their own achievements against the achievements of others, e.g. using leaderboards. This can introduce a competitive element for users acting within the domain and is a relatively straightforward approach as it does not require the core task to be modified in order to play the game. The aim of playing this kind of game is can be summarised as attaining the highest score. However, in order to do so, and dependent upon the associated points model, the user may have to change the way that they complete their chosen tasks, or even perform different tasks entirely to accumulate the greatest reward. By balancing the accumulation of points against the available tasks, the users original behaviour may change in line with outcomes planned by the game designers, hence this approach provides a strong link between gamification and behaviour management techniques.

Modifying or extending existing core tasks to incorporate some element of play is a reliable way to transform the process of completing a mundane task into something that can be more fun to do. By carefully balancing which tasks are gamified with those tasks that arent, the interaction can be designed to favour particular behaviours. Both metrified and modified tasks can be combined to provide further flexibility in the design of an engaging and persuasive platform. By incorporating these kinds of features, gamification aims to increase both long and short term user uptake and acceptance whilst simulataneously making the system both fun and engaging. It is this target that SUPERHUB is aiming for, an engaging and rewarding behaviour change experience.

3 The Gamification Model (PAG-M)

In this section we discuss elements of the Points Accumulation Gamification model (PAG-M) which underpins the gamified aspects of travel using SUPERHUB and relate this to the sustainable travel problem domain. In the remainder of this section we introduce and discuss points accumulation, levels, badges, and challenges. Points are the most basic gamification element within this model, on which are built a number of more complex constructs enabling goal-oriented behaviour, engagement, and social interaction to be facilliated and managed at different levels of complexity in order to provide a more richer environment for exploring behaviour change.

In PAG-M, users accumulate points for engaging in behaviours that the system deems to be positive, and, in the abstract model but not presently in SUPERHUB, there is the potential to remove points when a negative behaviour is measured. When a user engages in a given behaviour a number of points can be allocated according to the specific behaviour concerned. Points can be allocated either directly, to the user who performed the behaviour, or indirectly, for example to a group of users other than the performing user but who are in some way related to the performing user, e.g a peer-group that have an existing and declared relationship with the user that is otherwise captured by the system. The number of points allocated can be either fixed for all users or variable depending upon segmentation factors associated with individual users. For example, giving a larger award to a car user for taking a cycle journey than to a regular cyclist might be more likely to encourage a change towards a sustainable behaviour, whereas for the regular cyclist the reward is more of a behaviour maintenance allocation.

Rather than merely accumulating an increasing but otherwise undifferentiated number of points, users can level-up; their accumulation of points is translated into discrete levels that enable broad comparison of attainment according to levels. The transition between levels can occur in a number of ways such as with fixed and discrete transitions at predefined scores or with personalised levels calculated on a per-user basis. It should be noted however that if individual scores are set then it becomes difficult to directly compare the performance of individual users which might have repercussions if the system is subsequently deployed in a more social context. The scores required to trigger a level transition can be either fixed or variable, for example, the level could increase every time the user reached a score of 1000 points. Alternatively, the score could be a linearly, or otherwise, increasing amount, making progress slower as participants reached higher levels. However, such an approach might require additional incentives, such as opportunities to earn large numbers of points, so as to avoid the users participation level from dropping as a consequence. In determining a points based mechanism for gamifying interactions, such factors must be taken into account to balance the needs of novice users who are just beginning to develop new behaviours from those of more experienced users who are maintaining habits.

In non-computational contexts, badges are used to communicate and to signify status. It is the status role that is most commonly exploited when badges are deployed within gamified interactions. Badges can indicate that a user has achieved a particular level of success either by achieving particular goals or by accumulating sufficient points to achieve a defined status. Badges can thus play a social role, signifying to other users the status and achievements of the badged user, whilst also playing a more private role to users, as a kind of virtual reward. This can satisfy the need to aquire and collect, and can play an important role in facililtating greater user engagement as well as inter-user competition.

Challenges capture the idea of setting a particular goal, the achievement of which will earn a larger number of points, and whose solution is not necessarily straightforward, e.g. the goal in a challenge can be a higher-level, more complex achievement, such as reducing your personal carbon footprint, however there are a variety of tasks that can be performed to achieve this. This enable the basic complete tasks to earn points interaction to be made more interesting and challenging for the user. By offering the user the opportunity to formulate solutions to challenges for themselves the aim is to facillitate greater engagement and greater satisfaction. Challenges can be of several types; those set by the system and directed at either individuals or groups of users, those set by users and directed towards others, and those set by users for themselves. This offers the opportunity to provide socially oriented, almost competitive, challenge interactions, as well as a personalised, individual, private, self-improvement interactions.

The MDA framework of game design [5] describes how games are composed from three elements: Mechanics, Dynamics, and Aesthetics. Mechanics define the parts of the game, for example the pieces, tokens, boards, or gamespace. Dynamics define how the pieces are placed, arranged, and moved in relation to one another. Aesthetics define the feelings that the composition of mechanics and dynamics engenders in the players. PAG-M is therefore situated across these levels, operating at both the mechanical and dynamic layers, and ultimately designed to affect the aesthetics of the interaction. The aim of applying PAG-M within SUPERHUB is to engender real, lasting change, and an element of that is to create an emotional response in SUPERHUB users.

Given the widespread and well understood use of points and levels as a way to mark progress within games and competition in popular culture, one might pose the question: why is it necessary to cover similar ground in detail now? In answer to this, we suggest that such an approach gives us a reference point from which to build our solution within the sustainable travel problem domain, and enables us to fix the terminology with which we describe our solution. A second reason for taking this two-fold approach, developing a higher-level abstract model of points based gamification and a low-level, concrete implementation, is to enable the construction of more generally applicable gamification support in software tools that are designed to tackle societal problems both on a large scale and in a repeatable, and robust way. Finally, the recent CHI workshop Designing Gamification [1] identified that whilst gamification has recently become a popular technique in both HCI and the wider software industry, there is still little knowledge about the effective design of such systems whether as an additional layer to extant software or the wholesale design of new gamified systems from the ground up. We aim to tackle this issue by developing a core model that captures the essential elements of our approach to gamification and which can be extended to a range of problem domains either incorporated within existing systems or as the basis for new systems.

4 Applying PAG-M Within SUPERHUB

In this section we make concrete those specific aspects of the higher-level model, introduced in the previous section, by describing how the abstract notions of points and levels are instantiated within the SUPERHUB platform. In this way we distinguish between the flexible, higher-level model described earlier which necessarily has wider scope and capabilities and the narrower and more specific utilisation and implementation within SUPERHUB.

From a motivational perspective, in SUPERHUB we aim to encourage two factors. Firstly increased usage of the SUPERHUB apps, and secondly, increased frequency and choice of sustainable travel behaviours. We prioritise usage of SUPERHUB as our first factor because the core mission of the platform is to facilitate sustainable urban travel. Hence we assume that ceteris paribus increased SUPERHUB usage will lead to increasingly sustainable travel amongst SUPERHUB users.

New users join SUPERHUB at level one with a score of zero points. Subsequently, as the user accumulates an increasing number of points, they progress to higher levels. This gives the user an indication of their progress over time. Points can be collected for performing tasks and the range of available points varies depending upon the particular task that is performed. For example, there are low-level maintenance tasks that enable smooth running of the system, for example, fine-tuning the recommender component which provides personalised travel recommendations, requires that the user provide feedback about historical recommendations. Similarly, personalisation of challenges and measurement of key performance indicators for the entire system are based upon knowing more about the user and therefore require more complete profile completion. Some of these tasks are one-off occurrences, for example, completing the basic profile, whereas other tasks are recurrent, for example, asking the user to rate a set of points of interest associated with a given journey plan in order to fine-tune the recommender. In both of these cases, increasingly accurate functionality of the system is based upon the user performing tasks which attract small numbers of points.

An early design decision that was made during the gamification design process was to award small numbers of points for lots of common tasks that an active user of SUPERHUB might perform, for example, planning and selecting a journey, rating a complete journey, rating individual POIs within a journey in relation to their interest to the user, and reporting disruptive events could attract a lower number of points rewards. These are regularly recurring interactions that any user of SUPERHUB might commonly be expected to perform. The idea here is merely to encourage increased use of SUPERHUB so, just by using the system, users are accumulating points and can see that they are progressing. By taking this approach we are also able to tackle one of our bootstrap problems, specifically, a knowledge bottleneck associated with the fact that some of the functional components of the system both work better in general and work more accurately for individual users when there is more information in total and more information about individuals. In SUPERHUB larger amounts of points are awarded for successfully completing tasks associated with sustainable travel. For example, given a set of alternative journey plans which include a range of different, multi-modal, travel options and which are ranked in terms of their CO2 emissions, a user could be awarded more points for selecting and completing a journey that has lower emissions than one that has higher emissions.

Within SUPERHUB, we only allow points to accumulate, users cannot lose points. This decision reflects the idea that whilst a traveller can aim to be environmentally sustainable in everything they do they cannot always control all aspects of the journeys that they make and such users should not be penalised for those journeys that they make that are outwith their control. Because SUPERHUB aims to support all travellers within a city, whether travelling for business, leisure, tourism, or any other reason, and some of those travellers may make journeys, for example business journeys by taxi, that run counter to their personal travel preferences it is better to reward the more sustainable journeys than to punish the less sustainable.

SUPERHUB also supports self-organised challenges which enable a user to pursue a higher level goal. Goal-based challenges are built atop the basic points and level mechanisms and enable users to set for themselves a personalised goal that they wish to satisfy and the successful completion of which will earn them points. The platform currently support 3 types of challenge which relate directly to the users CO2 emissions, the money that they spend on their travel, and the calories burnt in travelling. Whilst it would be ideal if all users were motivated primarily by environmental concerns, and hence would compete in CO2 reduction challenges, we recognise that many users have other priorities, for example, many users would prefer to save money, over concerns about either the environment or the amount of exercise that they took. However, whilst reduction of CO2 emissions aligns directly with moving people to more sustainable travel options, a saving money goal can do the same. Generally, those transport modes that are individual and motorised are more expensive than either mass-transit or non-motorised modes, for example, the cost of taking a taxi is generally far in excess of the cost of taking a bus or tram. Therefore a goal of saving money on travel costs can align with a change of behaviour from taking taxis to using mass-transit, in which case there is a consequent CO2 savings as the carbon burden, although larger in total for mass-transit, is amortised over a greater number of travellers. Similarly, a goal of burning more calories, which might be set by users who are primarily motivated to get more exercise or to increase their health, can also align with increasingly sustainable transport. Walking and cycling are both active travel modes which will increase the amount of calories spent whilst simultaneously reducing a users CO2 emissions. In this way we support approaches that are directed at those users who are primarily motivated by issues of sustainability and which directly affect the environment, whilst also supporting users who are not motivated in the same way, but by satisfying the users other motivations, we can indirectly help the environment.

By using a range of techniques, incorporating points and levels, and building a challenge platform atop of them we have developed a scalable system that supports motivated travellers who want to increase the sustainability of their travel behaviours, whilst also supporting other users whose motivations may be differently oriented but who can be exposed to and encouraged to act sustainably through less direct means. In this way we reinforce the primary goal of SUPERHUB which is to foster, to facilitate, and to support sustainable travel behaviours whilst acknowledging that in the real world, people have a range of motivations and these are not always aligned with environmental sustainability goals.

5 Implementation Within SUPERHUB & Example Challenge Usage

The SUPERHUB platform has a distributed, component-oriented architecture which supports multi-modal journey planning and resourcing, personalised recommendations, and behaviour change for environmentally sustainable travel. There are also a range of supplementary functionalities, such as crowd-sourced disruptive event reporting, social media and transport data-feed scanning, open-streetmap tile servers, and address autocompletion that aim to make the user experience more self-contained, more comprehensive, and more accurate.

For challenges we make use of the supplementary data about each individual journey plan that is provided by the planner as well as the challenges set by the user within their account. When a user searches for a journey, they are presented with a range of possible multi-modal routes and for each one total CO2 emissions, duration, cost, length, effort and satisfaction values are calculated as indicated in Figure 1. These are used as the basis for determining how a given journey contributes to the users current challenge.

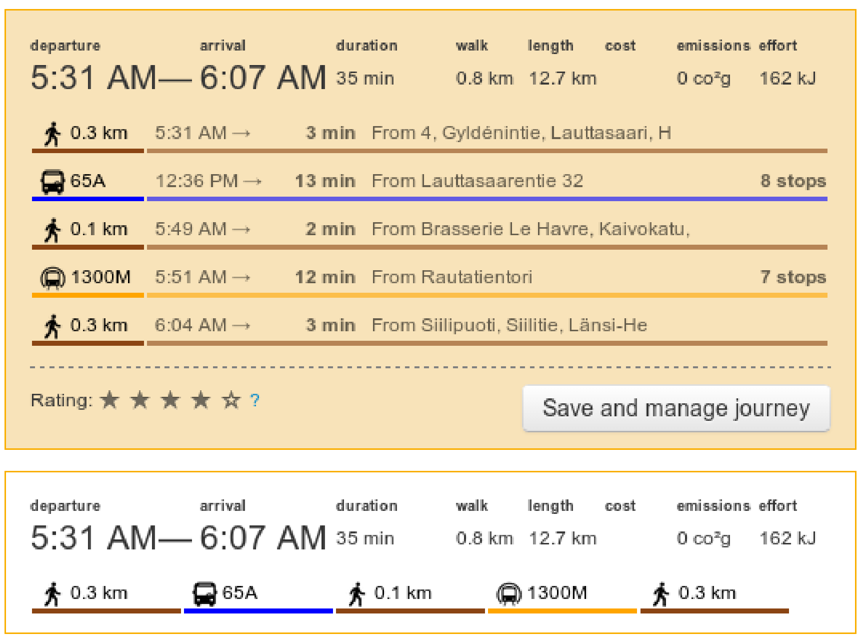

Fig. 1 Example output from the multi-modal journey planner indicating the various parameters that are calculated for each journey and which are subsequenty utilised by the challenge functionality.

The challenge process is as follows; the user accesses their SUPERHUB account and navigates to the goals functionality. The user is presented with options to set challenges relating to money, calories, or emissions. In this paper we use the emissions challenge as an exemplar but the other goals work in a similar fashion so emissions are representative.

The users can (without having to participate in a challenge) view their previous journeys, provided theyve been planned with SUPERHUB, as well as visualise different aspects (CO2 emissions, calories burned etc.) of individual past journeys or aggregated over freely specifiable periods of time. Also retrievable from the usage data stored in the platform are all other plans offered to the user, but which were ultimately discarded for the favor of the one journey plan which suited the user best at the time of planning.

For each user, using the data described above, its possible to calculate overall indices for each aspect/criterion representing how much of that criterion they tolerated in relation to the worst case. For example, if over the course of their entire SUPERHUB history, a user could have emitted 20kg of CO2 by choosing a car every time, but instead chose journeys which caused only 10kg of CO2 emissions, their CO2 index would be 50%. See Figure 2 for clarification.

The challenges are designed to reward improvement compared to a users behavioural history. In other words, challenges are short time frames (in the current application arbitrarily set to a week, constrained by the length of the trial period) in which the user must try to choose journeys resulting in a better relative score than their entire travel history. This way, even heavy car users can complete a challenge with success if they set a target of e.g. 80%, allowing them to still take about of their journeys with a car (caveat: previous is true if all journeys they take are the same length - the lengths of the trips obviously affect the score). Naturally, the better the target score, the more points will be awarded on success.

To mitigate exploits of the system, the user is limited to only having one active challenge per criterion at a time. Also, a minimum of 5 journeys must be planned and taken (as recognized by the activity tracker of the Android app) in order to complete a challenge as illustrated in Figure 3. s

We plan to include feedback during journey planning to help remind the user to keep in mind their ongoing challenges and how the journeys they take affect the outcomes. When the user plans a journey and saves a plan, the backend updates the values and state of any ongoing challenges the user might have. Finally, users are given visual feedback as to the status of their current challenge as indicated in Figure 4 for a failing challenge and Figure 5 for a successful challenge.

By taking this approach, and making challenges the main way to accumulate large numbers of points, we aim to build a system in which users are active in choosing to perform behaviours that are commensurate with their goals, and are offered many system supported opportunities to be introspective with respect to their travel behaviours.

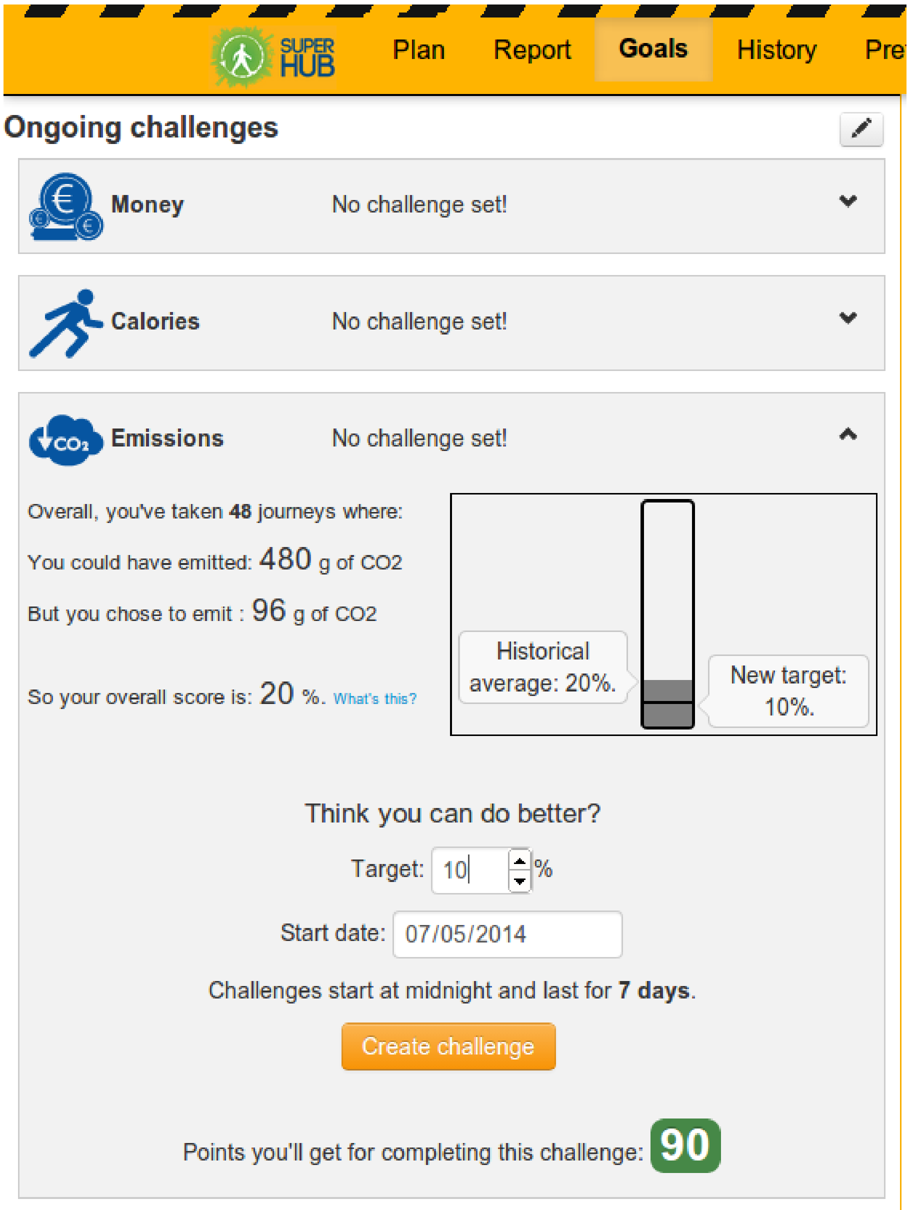

Fig. 2 Challenge setting screen. User is shown the i) number of journeys theyve taken, ii) amount of CO2 they could have emitted, iii) amount of CO2 they emitted by choice of journey plan, and iv) their resulting overall score/index. A bar/visual representation is also shown. As the users adjust the target for their challenge, the points promised for a successful completion is updated.

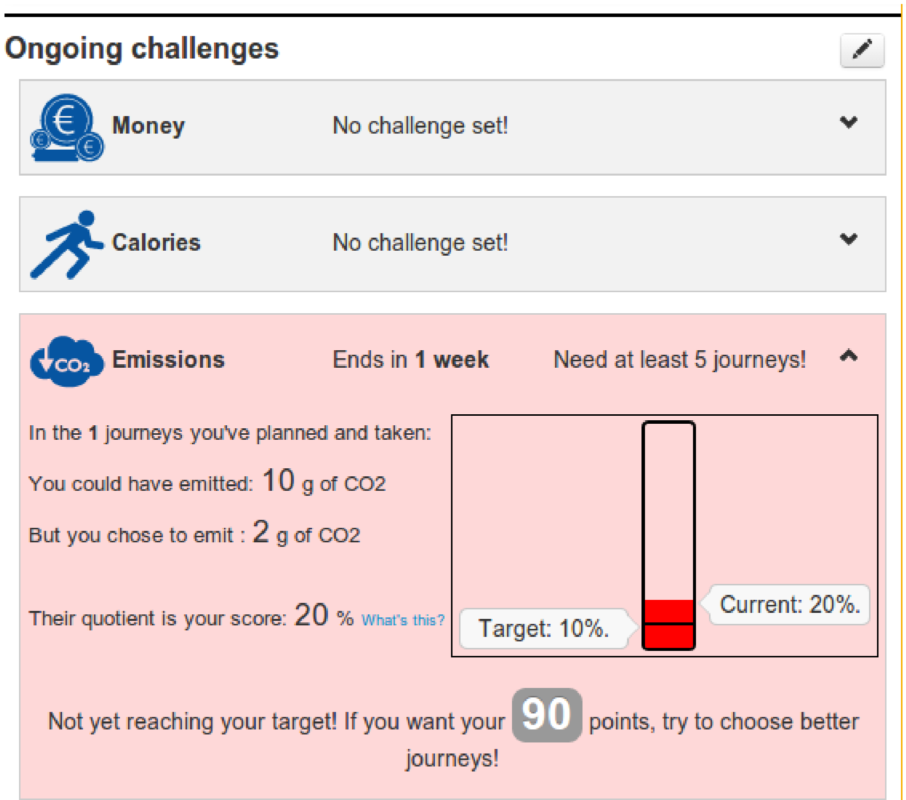

Fig. 3 Illustrating the requirement to complete a minimum number of journey in order to not 'game' the system.

6 Supporting Longer Term Behaviour Change

Behaviour modification, and the ensuing formation of new habits, is a difficult task to achieve and manage. This requires not only that the users current habits are modified, but also that their new habits are sustained, perhaps indefinitely. Over a longer timescale, the parameters of what might be considered an acceptable habit may change. For example, within SUPERHUB the mobility of a user, and therefore the appropriate range of desirable and sustainable travel behaviours particular to that user, may change over time as a function of many parameters, including but not limited to health, social status, family status, and age. As a result the system must be sufficiently flexible to enable either new, or modified, habits to be targeted. During deployment, it is expected that the balance of points available on a per task basis must be adjusted in order to manage both user expectations and user performance. As a result we envisage that management and balancing of a points based system is a long term task that must extend across the lifetime of the systems deployment.

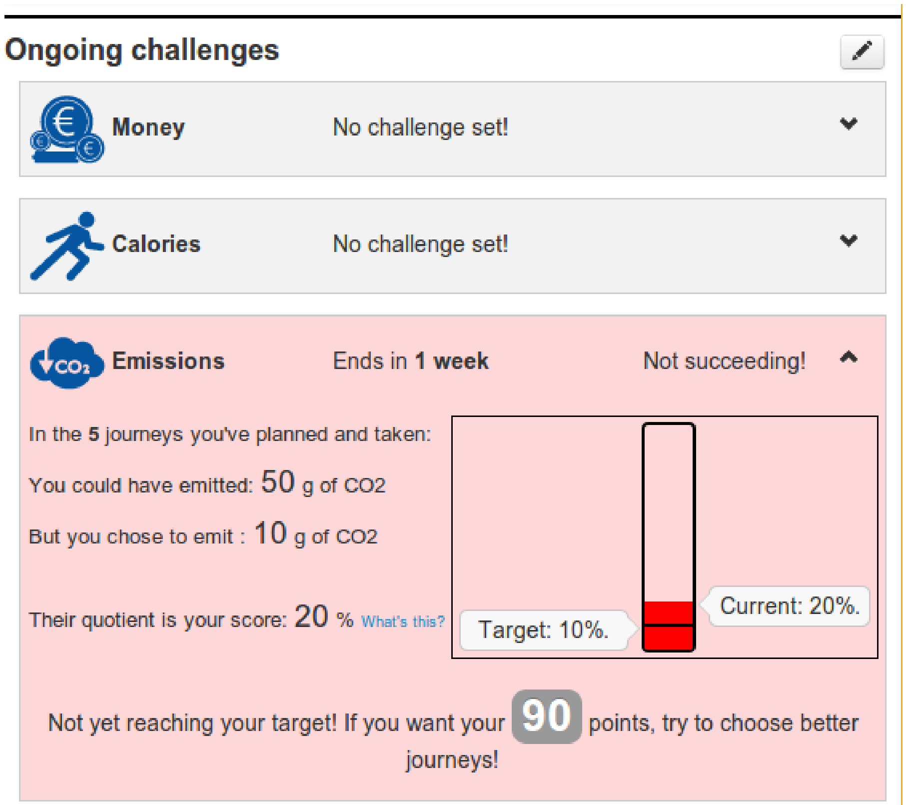

Fig. 4 This figure illustrates the challenge screen that is displayed to the user when they are failing a challenge.

Furthermore, habits must be formed by many users of the system in order to have a measurable effect at the city-wide level. To target many people for behaviour change requires the adoption of flexible techniques that can be modified to apply to users as individuals, with their own beliefs, goals, and pre-existing patterns of behaviour. What is an effective behavioural intervention for one user may not be as effective for the next, hence we must treat each user as an individual and personalise their experience of, and interaction with, the system.

Therefore we require a system that is both flexible, enabling it to target a wide, perhaps even dynamic, range of habits, and personalisable, enabling interventions, goals, and challenges to be targeted to the characteristics of individual users. Furthermore the system should support usage over the longer-term, providing feedback and a sense of progress to ensure that the experience does not become stale and so that users do not abandon the system as a result.

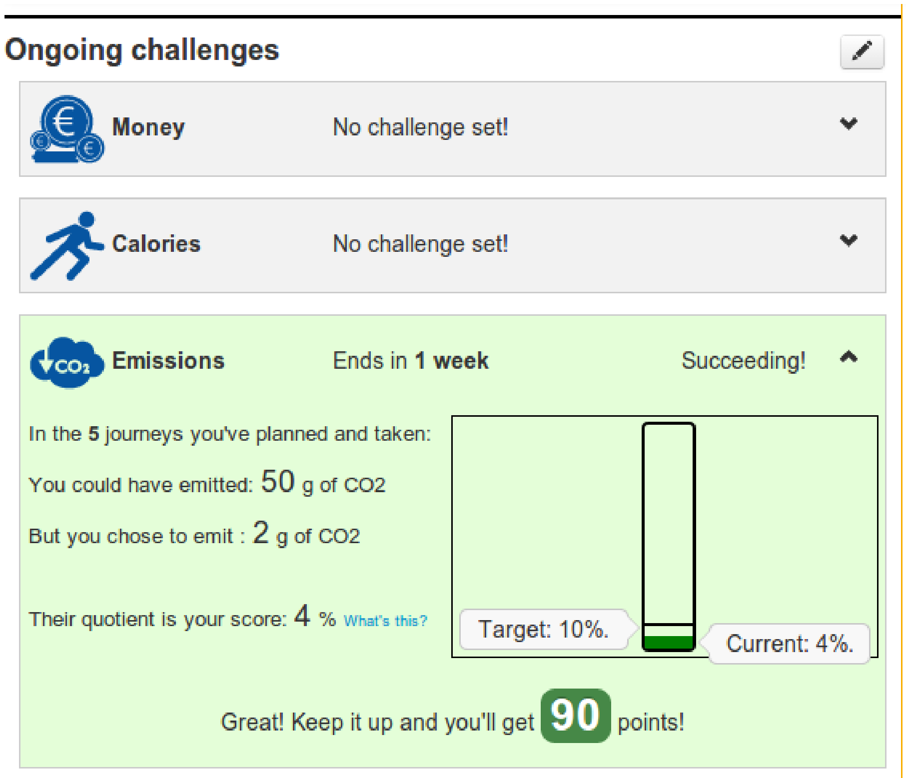

Fig. 5 This figure illustrates the challenge screen that is displayed to the user when they are succeeding in a challenge.

7 Bootstrapping The System

One aspect of creating and deploying a new system that can be problematic is bootstrapping the system to a sustainable level of usage. Social systems require a sufficient number of users for any social mechanisms to function correctly. If aspects of the systems functionality require a minimum number of users, for example, to provide activity data from which statistical baselines can be calculated, then for the system to function correctly, users must be attracted and retained. One solution to this problem, which aligns neatly with the point accumulation strategy, is to disburse real world rewards to users based upon their interaction with the system. Essentially, SUPERHUB allows users to redeem their points in exchange for items of real world value such as reduced fares on public transport and discounts on cycle sharing schemes.

Adoption of these approaches leads to a number of new challenges associated with ensuring that gamesmanship does not bankrupt the system and that user behaviour is directed toward desirable outcomes rather than merely towards those outcomes that accumulate the most rewards. This suggests that an ongoing adjustment of goals, triggers, and outcomes during deployment may be necessary whilst also taking steps to avoid a potential arms race with those users who might seek to exploit loopholes in the game rules.

8 Conclusions & Further Work

In this paper we have presented aspects of the model of points accumulation used in SUPERHUB. We have also described the goal-based behaviour management system that it underpins and explored the benefits of taking this approach. The SUPERHUB platform will be deployed in a second round of large-scale trials during Summer 2014 and results from this will be used to gauge the efficacy of the current system and to inform any subsequent development and refinement. We do however already have a range of directions that we would like to take the work in.

For longer term deployments of a goal-oriented challenge system efficient management and support tools are required. These would enable new challenge types to be defined, for the points allocation to be refined, and for the available real-world rewards to be altered and changed at run-time. Extending this idea further, machine learning tools could be deployed to support the recognition of new challenge types and to identify trends in point accumulation across the cohort of users. This would support the human-based management of the system with solid big data analysis leading, ideally, to a more robust, accurate and flexible system that can scale to very large numbers of users. Such an approach, utilising automated support tools of this type would prove invaluable, and would enable SUPERHUB to be deployed on a truly large scale. Additionally, by considering a more comprehensive set of points related behaviour management tactics we can ensure that the gamification approach taken in SUPERHUB can be adjusted to fit a wider range of problem domains.

In the current system all points accumulation is a completely individual affair. An individual user is the only recipient of points allocated as a result of their own behaviours. However it would be interesting to investigate how rewarding members of a subset of a persons social graph, based upon that persons behaviour, subsequently affects the perceived value of the reward. We would hope that for some users, such altruistic behaviour with the aim of increasing or maximising social gain is more important than individual gain. Therefore there is a rich thread of altruistic rewards that could be explored within SUPERHUB as we increase the amount of social functionality.

Finally, we aim to deploy similar gamification models in subsequent projects in other problem domains in order to gauge the general efficacy of this kind of approach. Our goal is to produce successful, repeatable behavioural interventions and behaviour change support tools which are generally applicable to societal problems and that can be incorporated into a wide range of domains, tools, and software platforms.

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