Social Mpower: An Educational Game for Energy Efficiency

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Abstract. A number of serious games have been developed for energy systems that act as an educational tool and help energy consumers to better understand concepts such as resource allocation, electricity prices and grid sustainability. In such gamified environments, players use technology to solve environmental problems including greener environment, optimised energy and water infrastructure, sustainable resources and reduced energy use. *Social Mpower* game is a representation of an autonomous energy community for local power generation and distribution in which the participants have to avoid a collective blackout by individually reducing their energy consumption by synchronising and coordinating their actions. Our experimental hypothesis is that collective awareness can be enhanced by appropriate features of the game interface, and therefore to increase the opportunities and prospects for successful collective action (e.g to avoid a blackout).

Keywords: educational game, energy efficiency, serious games

1 Introduction

Collective awareness has been informally defined as "an attribute of communities that helps their members to solve collective action problems" [2]. In this paper, we investigate the proposition that collective awareness can be enhanced by Information and Communication Technologies (ICT) with the appropriate affordances, therefore increasing the opportunities and prospects for successful collective action. This investigation is based on the development of a serious game, *Social Mpower*, in which participants have to avoid a collective blackout in a community energy system, by individually reducing their energy consumption through synchronisation and coordination of their actions.

Accordingly, this paper is structured as follows. In Section 2 we go deeper into the background and motivation for this research where we define collective awareness and we present serious games. Section 3 describes the design of the game interface which focuses on different interface features; interface cues, visualisation, social networking, feedback and incentives. Section 4 presents the

Social Mpower game and in Section 5 we report the results of the experiments, which show that the more cues for collective awareness that are added, the more often the users can coordinate their behaviour to avoid a blackout. Section 6 describes how this game can be used as an educational tool. Finally, we conclude with some remarks on the experimental results in Section 7.

2 Background & Motivation

In this section we present the background and motivation for our research. Collective awareness is a pre-requisite for successful collective action in communities and has to be shaped through affordances of the 'human-infrastructure interface'. Serious games are extensively used to simulate real-world events and they are designed to train or educate people on science, health care, management, engineering and so on. Energy systems are a particular area where serious games have been widely deployed to achieve a desired progress or change in players' behaviour.

2.1 Collective Awareness

Collective awareness is informally defined as "an attribute of communities that helps them solve collective action problems", i.e. analogous to the way that social capital is defined by Ostrom and Ahn [12] as "an attribute of individuals that helps them solve collective action problems". Collective awareness is a critical aspect within communities which promotes collective action; members of communities take the necessary actions as a synchronised and accumulated body to reach a desirable outcome for collective resources and services – water, electricity and data [13].

Collective awareness is the common knowledge that comes from social networking, self-organisation and coordination, and it is the essential link between self-organising communities and successful collective action [14]. In communities in which collective awareness is absent, individuals are generally less willing to obey the norms or the rules, or able to understand that their actions have an effect on the community [5]. Individuals may understand the situation they are in from a micro-level perspective (e.g. reducing individual energy consumption) and might additionally recognise the macro-level requirement (e.g. meeting national carbon dioxide emission pledges); however, they might not be aware of interactions occurring at the meso-level which are critical for mapping one to the other [16]. There are communities where common resources are not sufficient for all their members, and the lack of collective awareness may prohibit individuals from changing their community behaviour or even taking actions that may lead to depletion of those resources [2]. Collective awareness can contribute to an efficient resource allocation within a community, ensuring at the same time the long-term sustainability of that community [1], [15].

2.2 Serious Games

Games are activities among two or more independent decision-makers who want to achieve their goals in a specific environment. In the context of a game there are rules, and players compete against their adversaries to meet their objectives. But not all games are competitions; there are games where players cooperate to achieve a common goal and there are no individual objectives. Games may be played just for fun but there are games, called serious games, which have a clear and intentional educational purpose and they are not intended primarily for entertainment [9].

Serious games are extensively used to simulate real-world events, inform or make players aware, and trigger their problem-solving skills. These games prepare people to work smarter by enabling them to visualise their actions and explore different events in an intuitive way. Serious games are games in which education in various forms is the primary goal rather than entertainment, and they help users to develop skills such as decision-making, critical thinking and analytical skills [8], [3], [6]. They are experiential environments that use characteristics of games to deliver a message, teach a lesson or provide an experience. The main goal of these games is to educate players while they entertain them. Serious games are very effective in teaching and training players despite their age and they can communicate their concepts in a very efficient way. Players, through their roles, solve problems, set strategies and make decisions without facing the cost of real world consequences. Serious games allow players not only to learn but also to apply and show what they learned during the gameplay [11].

3 Interface Design

Five interface features have been identified as sufficient conditions to promote collective awareness for successful collective action, and the design of the *Social Mpower* interface focused on them; interface cues, visualisation, social networking, feedback and incentives [2].

1. Interface cues: In *Social Mpower* interface, different interface cues are introduced to induce users to participate in a collective-action situation. Interface cues are used to guide the user interface interaction and communicate different behaviours to users. Users are informed about the different tasks they should complete and receive feedback regarding their actions. Specifically, users become members of a virtual energy community whose objective is the resolution of a collective-action problem; within a specific amount of available energy, users should complete specific tasks. The graphical cues inform users (e.g. send alerts) about upcoming problems and emphasise users' actions and states of the system. A SmartMeter display board is used as a graphical cue whose objective is to inform users about their energy consumption both on individual and common basis, and displays the limit of the available energy. Textual cues are used to link the illustrated information

available on the SmartMeter display board with text messages that users receive regarding their energy consumption. Users can also get advice on how to solve potential problems, i.e. help information.

2. Visualisation: *Social Mpower* interface provides appropriate presentation and representation of data, making what is conceptually significant, perceptually prominent. Every house in *Social Mpower* has a SmartMeter display board. These boards display the energy consumption of every individual house and the total community consumption. The energy consumption is clearly illustrated through a line graph, where the lines have different colours depending on the information displayed each time, and they fluctuate based on the consumed power. There is another board in every home which shows the consumption of the most common kitchen appliances in percentage. This board helps users to estimate how much electricity each appliance is using.
3. Social networking: *Social Mpower* supports fast and convenient communication channels to support the propagation of data. Users could take advantage of the different types of text chat to communicate upcoming energy problems and coordinate with others a plan or schedule to avoid them. Communication helps in self-organisation and resolution of collective-action problems.
4. Feedback: In *Social Mpower*, users should know that their ('small', individual) action X contributes to some ('large', collective) action Y which achieves beneficial outcome Z. In many collective-action situations, individual users may not recognise that their small actions can contribute to resolve a problem, especially if the effect is indirect, undetectable or long-term (e.g. climate change). Real-time feedback includes all the necessary information (e.g. power consumption of electrical appliances) that users should know to proactively coordinate their behaviour and take collective actions to prevent energy problems.
5. Incentives: Rewards and incentives typically in the form of social capital (itself identified as an attribute of individuals that helps them with solving collective action problems [12]) give to users a sense of achievement when they avoid energy problems. The rewards are assessed at the end of the game and are given to players who have completed their tasks without having exceeded their energy limit. Introducing social capital mechanisms and rewards in form of prizes to *Social Mpower* interface, benefit users both in individual and group level, as these mechanisms and rewards support and promote successful collective action.

4 Social Mpower: An Overview

Social Mpower game is a representation of a community energy system for local power generation and distribution, true to detail and as realistic as possible. This game creates a unique experience to players who can observe the immediate weather changes and the use of renewable energy. We wanted to create a game which is easy-to-understand and portrays the energy community of the future. Power generation results from Photovoltaic (PV) cells which are the only energy

sources for the community and they are installed on the roofs of the virtual residences. The virtual residences are connected so that they consume the produced power and eventually share any remaining energy with the rest of the residences. The produced energy is stored in each residence in appropriate energy storage systems. *Social Mpower* challenges the player to sustain the energy system of the community, where the player takes the role of a consumer in a rural area and whose task is to avoid the depletion of the available resources.

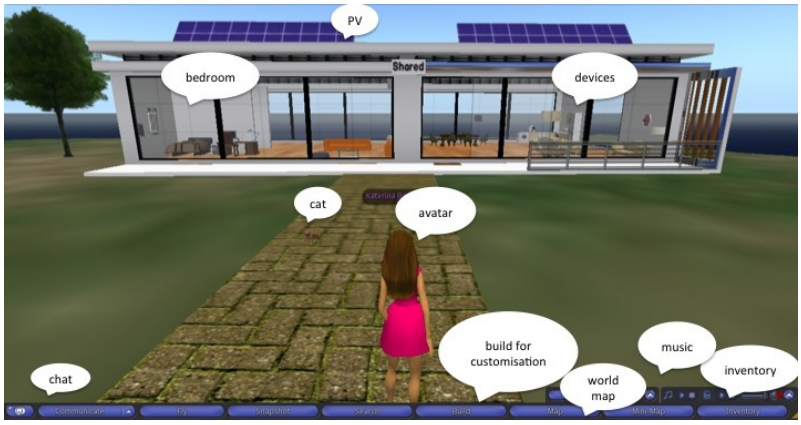

Fig. 1. Social Mpower virtual world

Figure 1 presents a screen capture of *Social Mpower* interface; PV cells installed on the roofs of the residence generate the required power for the community, whereas the home devices use the produced electricity. Bedrooms are included in the house to make players feel like home, and animals (i.e. cat) increase the game recreation. The graphical representation of the user, avatar, can be customised to meet user's requirements, while the 'build' option enables users to personalise their virtual environment. In the inventory, players can save and store their virtual assets and objects, and via chat they can communicate with other in-world avatars. Users can listen to music while playing, and with the world map option they can see in miniature the whole virtual world.

The virtual community consists of three types of residences; single, couple and shared house. These houses accommodate the same electrical appliances, but the number of appliances in every house may vary.

5 Experimental Results

87 players took part in the experiments, separated into groups of 2 or 3 players, and each experiment lasted about 30 minutes. Our proposition (experimental hypothesis) was that the more interface features we added to the game interface that increased collective awareness, the more our players would cooperate

to avoid a collective action problem. Logistic regression, a direct probability model, was used to calculate the percentage that players, given the different interface features, managed to coordinate their actions and avoid a blackout. Table 1 presents a summary of the results; percentage of players who managed to coordinate their actions and thus avoid an energy problem given different combinations of the interface requirements enabled on the game interface.

Table 1. Percentage of players who coordinated their actions

Interface Features	***Percentage of coordination***
No Interface Feature	43.7%
SmartMeter	55.2%
Chat	73.6%
Rewards	42.5%
Real-Time Feedback	55.2%
SmartMeter & Real-Time Feedback	57.5%
SmartMeter & Chat	62.1%
SmartMeter & Rewards	56.3%
Chat & Rewards	73.6%
Chat & Real-Time Feedback	73.6%
Real-Time Feedback & Rewards	55.2%
SmartMeter, Rewards & Feedback	57.5%
SmartMeter, Feedback & Chat	73.6%
SmartMeter, Rewards & Chat	74.7%
Real-Time Feedback, Rewards & Chat	73.6%
SmartMeter, Real-Time Feedback, Rewards & Chat	73.6%

When no interface feature was enabled on the *Social Mpower* interface, only 43.7% of players managed to coordinate their actions and avoid an energy problem. Adding the different interface features, this percentage increased. Just by adding social networking in the form of chat, we found that we could achieve a successful collective action (e.g avoid a blackout). However, the other interface features were having another effect. Players avoided fragmentation and re-built community spirit for long-term engagement, and the educational purposes prior to gamification prepared players for the 'real-thing'; they learned to trust each other before they are let loose on a real life community energy system.

Based on the experimental results, we can now use *Social Mpower* in an educational context and as a stepping stone to gamification and real community energy systems.

6 Social Mpower: An Educational Game

In *Social Mpower*, players are members of a community and their goal is to prevent energy problems. The use of a simulated environment helps in educating players fast and effectively. There are no consequences when players do something

wrong during the gameplay as they learn how to avoid problems and take better actions and decisions regarding real life problems. With *Social Mpower* game, players develop social and cognitive skills, and they gain the required confidence to engage with virtual worlds.

Players explore new activities and experiences, communicate with other in-world players and practise new skills [7], [17]. At the end of each game, players receive feedback in the form of instant messages and advices regarding their energy use which challenge their critical thinking and understanding of electricity [10]. *Social Mpower* enables players to understand how the power generation and distribution network works, and through different tasks they learn how energy communities can actually use the different technologies to become energy sustainable and efficient.

Social Mpower combines learning with fun and recreation. Through voluntary play and without extrinsic goals that force learning, this game actively engage players. Creativity is promoted tremendously as players can be involved in constructing buildings and objects, personalising their avatars and residences, or even using the different engaging elements that are available in the virtual world to enhance their game experience. *Social Mpower* game is a process to learning rather than a predicted outcome, and it raises strong motivation for energy efficiency [4]. Using the experience from a virtual world, players can build new knowledge and understanding in different energy-related contexts which stimulate and support their skill development.

The educational aim of *Social Mpower* is not only to make the energy system that serves the virtual community more efficient, but also to enable players to understand that they should unite into a group to effectively resolve a collective action problem. Players should recognise that they are impacted in a collective action situation, and that any small individual action will contribute to resolving any upcoming problems. Especially in the energy sector, if players are "collective aware" of an incipient energy problem they can proactively coordinate their behaviour to take a collective action to prevent it. *Social Mpower* awares individuals to take actions regarding common resources that are suboptimal from a community-wide perspective without leading to the depletion of those resources. Players are led towards successful action through self-organisation and social networking promoted via the game interface.

7 Summary & Conclusions

In this paper we presented the *Social Mpower* game, a serious game in which players have to avoid a collective energy problem (e.g. blackout) by individually reducing their energy consumption. The design of the *Social Mpower* interface is based on five interface requirements which enhance collective awareness; interface cues, visualisation, social networking, feedback and incentives. The experimental results gave us empirical evidence on whether the proposed interface features were successful to promote collective awareness for successful collective action in an energy community system or not. Based on statistical analysis and

received feedback, visualisation, social networking, feedback and incentives enabled users to successfully coordinate their behaviour and avoid potential energy problems. Rewards in the form of prize were not a strong incentive for players to change their behaviour during the gameplay and thus, in future work new incentives/rewards should be examined and introduced to *Social Mpower* game.

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