Persuasive design of a mobile energy conservation game with direct feedback and social cues

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ABSTRACT

Pervasive gaming has the potential of transforming the home into a persuasive environment in which the user can learn about appliances and their electricity consumption. Power Explorer is a mobile game with a special sensing approach that provides real-time electricity measurements and feedback when the user switches on and off devices in the home. The game was developed based on persuasive principles to provide an engaging means to learn about energy with positive and negative feedback and social feedback from peers on real energy actions in the home. We present the design and rationale of this game and discuss how pervasive games can be viewed from a persuasive and learning point of view.

Author Keywords

Pervasive games, Motivation, Persuasion, Electricity Consumption, Persuasive games, Serious Game, Advergame.

INTRODUCTION

The present global environmental crisis requires new approaches for communicating the necessity of saving energy as a mean to the end of reducing emissions of carbon dioxide. Studies have shown that smart use of electricity and saving in the home has a potential of reducing electricity consumption in the home up to 30 percent [1]. Just small changes in personal habits are needed to accomplish significant energy savings.

A problem, however, is that the general public does not know what actions constitute wasteful use of electricity in the home. It is difficult to understand what activities and what devices that consume large amounts of electricity and how small individual actions may impact a homes' electricity consumption. Furthermore, it is known from research in advertising and communication that campaigns and information on urgent social topics, (e.g. quit smoking, don't ´drink and drive, use a condom etc), can be considered "a nag" and are filtered out [4, 19, 21, 24].

It has been put forth that computer games can be a way to persuade and educate the player into new attitudes and new behaviors [2, 9,17,16, 28, 29]. However, there is still little knowledge of how such games should be designed to enable learning, foster new behaviors and attitudes and break through the filters. For example, some salient questions in the area of learning game design is how to make the game engaging while keeping the message intact. That is, provide just the "right amount" of tips and information for the game not to become boring and get filtered out.

Moreover, researchers are questioning how effective computer games and consoles intrinsically can be in terms of promoting learning and behavior changes since they either often just provide a *simulation* of suitable actions in a virtual world and these may not be transferred to the real world [20], or lead the player to learn the game instead of the message [11].

In this paper, we suggest that pervasive games is a sub-genre of game design that has suitable properties as a home-genre for educational and persuasive purposes because gamers can be immersed in real tasks in the home and can get immediate feedback on those behaviors. Our approach is embodied in Power Explorer - an experimental game designed to promote energy awareness and aid gamers to learn about energy efficient actions in the home. The suggested game design can be said to be information-shallow since it provides no in-game informative content, no in-game tips on how to succeed and no overt topical information and pointers to avoid issues such as the nagging problem.

Instead, the game design relies entirely on shallow cues on own behaviors (in real time) and on basic social cues from peers. The paper is organized as follows: First, we present earlier research on pervasive games, feedback and cues. Second, we present the design components of Power Explorer. In the remainder of the paper, we relate the design components and our approach to theoretical aspects of persuasive design.

BACKGROUND

Pervasive games

The definition of the concept "pervasive game" is still the subject of some terminological and philosophical discourse [12,15,17,23]. The term, however, mostly implies some sort of reality expansion of the game. Montola, Stenros & Waern [23] have suggested that one can view pervasive

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games in terms of three expansions; *Spatial expansion* is probably the most salient trait of pervasive games and it means that the game "breaks its boundaries" and takes to the streets of the real world (this opposed to assumed "normal" digital games that are played on stationary standard computers and consoles). *Temporal expansion* is when a game expands the time structure of the play. When appropriating real-life objects into the game ordinary real-life objects get a new meaning and history. Temporal expansion can also mean that there is no "on" or "off"-time from the game. *Social expansion* is when the game includes ordinary people who are not actual players of the game, and who may or may not be aware they have become part of a game. A pervasive game can utilize the design of social expansion in controversial or benign ways. For example, the socially expanded research games Hot Potato,[1] utilizes mobile phones and Bluetooth transmissions and unwitting passersby as game resource for the players in ways that is intended to raise ethical issues. A game like Insectopia[2] also uses unwitting passersby as game resources, but in ways that may raise less ethical concerns.

Common for many pervasive games are that they in order to function need to rely on some sort of sensor system. There are two attributes to such a sensor system that are desirable. Firstly the system needs to fairly accurately interpret something in the real world that has meaning for the players. Secondly the system is preferably one that is feasible given the particular situation, i.e. not being to obtrusive, be scalable, offer enough coverage, be affordable etc.

The most popular choice of sensor system in pervasive games has so far been the GPS system. With the players' position a game designer can approximate players' locations towards each other as well as towards fictive or real objects. Examples of pervasive learning games utilizing GPS are Savannah [5], Rexplorer [26] and Frequency 1550 [8]. Savannah is played on a predefined open field where the participants take the roll of a pack of Lions hunting virtual animals. Rexplorer and Frequency 1550 both aims to teach the player about local history of a particular city. Power Agent [3] is a mobile pervasive game that utilizes the existing Automatic Meter Reading system (AMR) to measure the homes electricity consumption and provide feedback in the game.

[1] In Hot Potato, the players roam an urban area and pass a "Hot Potato" between themselves via Bluetooth. The players can "park" the potato on the mobile phone of an unwitting passerby via a form of "*blue jacking"*. Then the player, who has parked the potato, must take it back, the player is driven to follow the passerby in ways that may resemble stalking.

[2] Insectopia is a collection-game where the player collects "insects". The presence or absence of insects is defined by the presence of blue-tooth enabled devices in range. The passerby whose presence is a resource has no way of realizing that he/she is a resource in the players´ game. See: http://iperg.sics.se/iperg_games7.php.

The AMR approach to sensoring and data collection is clearly feasible since it already exists in place provided by some of the energy utility companies. The system however delays the feedback to a game built on it, since data in most cases is only transferred once every night. As a result Power Agent game design relies on ascendant intervention trough explicit clues and tips on how to save energy and is also very much played in a slow turn based event fashion.

In Power Explorer, the design case presented here, we will instead use a custom made real time sensor system to measure electric consumption in the home. Recent advances in consumer electronics have led us to the conclusion that this is now feasible, since similar solutions are provided by products like Wattson [27] and Eco-Eye [7].

Behavior, cues and learning

A fundamental part of the learning process is to get feedback on our actions [18, 22]. More recent research on behavior modification has suggested that behaviors can be controlled by adjusting the antecedents or the consequences of an action. That is controlling the possibilities for a person to take a certain action or controlling the feedback of an action. Examples of the former are physical barriers and designs that disallow certain behaviors. Another example is artifacts that invite and promote actions. Examples of the latter strategy are positive and negative feedback and reinforcements on actions in terms of directs rewards i.e. classical behaviorist approaches. Hence, strategies that can be said to frame the interpretation of an action.

An example relating to the use of electricity would be the Power Aware Cord by Gustafsson et. al [10]. Several studies have emphasized the importance of relating the two strategies and they have also underlined the need to contextualize and frame the feedback in time and place so that the subject can understand what the feedback was about.

Immediate feedback and contextualization has also been suggested as a means to change peoples´ energy consumption patterns in the home. For example, McCalley and colleagues have suggested that persuasive technologies that aim to promote energy conservation should provide informative feedback on the appliance-level, rather than on the aggregated household level because this would make it easier for the consumer to contextualize and understand the impact of an action [13,14].

POWER EXPLORER

Power Explorer is a pervasive action-oriented multiplayer game where the overall goal is to explore the household, learn about its´ electricity consuming devices and develop a positive attitude towards conserving electricity. The gamer can also engage in real time duels with peers, and winning those duels is based on manipulating household electricity consumption. At the onset, all players are assigned a medium sized CO2 cloud that will expand or disappear

depending on the use of electricity in the home. The goal is to keep your cloud smaller than your opponents' clouds.

System overview

In Power Explorer the entire home acts as a game interface through its electric appliances. The flow of electrons into the house is continuously analyzed by a small microcomputer wirelessly connected to the internet. The computer measures the magnetic field around main incoming electric cables trough clip-on sensors.

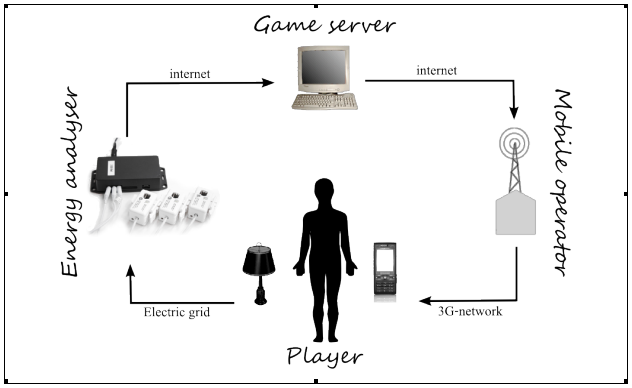

Figure 1. System overview

The results of the measurements are compressed and relayed to a game server. The game server compiles the results of all players and transmits appropriate data to each game client on the mobile phone over the UMTS network.

Game play

In Power Explorer all players and households are represented by their avatars – their own "monster blob". The Pile shows all players and their position in the game and it also provides means to invite peers to duels (see Figure 2).

Figure 2. The Pile shows all players and their position in the game. The pink monster with a red ring around is the current player's monster. The green sleeping monster with a golden scarf is the one who won the last duel. The monsters with closed eyes are players currently off-line.

A monster's position in the pile represents how much the household have been saving or consuming lately. Hence, the player at the top of the pile is the player who has made the currently largest decrease of consumption and has the smallest CO2 cloud in his yard, and the players at the bottom of the pile are the ones who have the biggest CO2 cloud. This setup also means that when household members are not home such as in the middle of a workday the drop in consumption can automatically result in a more prestigious position in the pile. Conversely, during weekends, when there are a lot of electricity consuming devices running, the player may automatically drop in the pile if the player does nothing about it. The same is simultaneously true for all players; one player may rise or fall in the pile, only due to the rhythms of daily life. This creates a dynamic that enables all players to feel that they have a fair chance in the competition.

To advance in the pile is, basically, a matter of exploring the home, identify the devices that are consuming a lot of electricity and turn them off. The meter on the left side of the pane shows the total consumption of the home in real time and, hence, it shows the consequences of turning on and off devices. To play in this mode is a relatively low-key, requiring little attention from the player as regards to the game console, itself but cognitive attention is required as regards to exploring devices and shaping everyday activities in the home.

Single player view

Power Explorer also provides other means to explore the energy environment of the home. In *the single player view,* the players´ own avatar is situated in its home, in the visual metaphor of a garden (see Figure 2). When the player or someone in the player's home turns a device on or off, a *flower* or a *weed* shoot up from the ground in the monster's home, and the avatar indefatigably consumes that weed. A weed shows up if the player increases the households' electricity consumption and a nice flower appears if the consumption decreases.

The size of the weed and the flowers indicate the amount of electricity variation[3]. This visualization of power changing events enables the player to map consumption levels to the current tasks performed. Hence, this playing mechanism allows gamers to investigate home appliances by turning them on and off and the game provides a direct feedback mechanism on the real-world actions.

The main problem with the weeds, is that when consumed by the monster blob, they give the avatar indigestion and this gives the avatar an unhappy face and make it puff out *carbon dioxide.* The rate of the CO2 puffs generated by the monster blob is the rate at which you are using energy (*i.e.,*

[3] This idea was to convey the notion of kilowatts.

power × *time*). The carbon dioxide accumulates in the grey cloud that overshadows the sky.

The CO2 from this cloud will spontaneously evaporate thus the cloud will disappear in time, as long as you don't add to the cloud by using electricity. The balance in this equation has been chosen so that a player needs to lower the consumption of the home with at least 15% in order for the cloud to start shrinking. The calculation is based on an average of the own household's electricity consumption a month before entry into the game[4]. Thus players compete with their relative consumption. If the players maintain their previous consumption the cloud will grow in size to eventually cover the entire screen. As a result the monster will get a lower position in the monster pile and become visible sick.

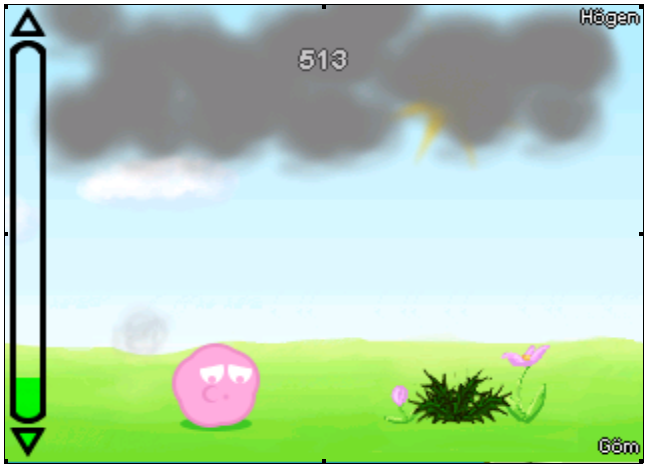

Figure 3. The single player view of Power Explorer. The player is doing rather badly and the avatar is unhappy due to the amount of thistles to consume and because the cloud of noxious carbon dioxide is large.

Duel modes

Power Explorer also offers an engaging real-time duel-mode where players can challenge any other player in the pile. Two duels are presently available in current version of the game.

Duel in the rain forest

The idea when designing the *Duel in the rain forest* was to bring learning about the amount of energy different devices burn when in continuous use. The key is to find the right level of energy.

This duel set the players´ two avatars running side by side on a racetrack in the middle of a rain forest. To win, the player has to reach the goal before the other player without running into too many of the obstacles along the way.

The obstacles will appear in cycles so the difficulty lies in timing them correctly. However, the running speed is determined by *manipulating* the household' electricity consumption. To win this duel i.e. to be able to adjust the running speed, the player needs to have an understanding of the *amount* of electricity different domestic appliances consume continuously. For example, turning *on* a microwave oven or a hairdryer – two big short-term electricity-consumers in a household – will result in a speedy avatar.

Figure 4. The Rainforest duel.

However, turning on appliances in order to increase running speed also has another effect. The added consumption of the two players' electricity consumption is connected to the amount of the precipitation in the rainforest. High consumption will therefore lead to a build-up of rainwater making both players drown (see Figure 4). Consequently, the task of the players' is to carefully maintain a balance between gaining enough speed to win the race, the right speed to time obstacles while not going to excess and drown.

Duel at the North Pole

The other duel is a fighting match on an iceberg at the North Pole (see Figure 5). In this game, the aim is to knock the opponent off the icecap into the water by throwing various objects. Small objects like snowballs, fish and seals have little impact on the opponent but polar bears and blue whales have a major impact on the rival. The player gets access to the objects by controlling the electricity consumption in the home. For example, to get a powerful whale the player has to understand that the task is to turn *on* a major electricity-consuming device such as an electric radiator, for a second or two. Hence, a short "spike" endows a player with an object.

[4] In this way, all players, whether major or minor electricity consumers, can compete on a level playing field and have equal chances of winning.

Figure 5. The North Pole duel.

Buttons on the console controls the throw direction while the destructiveness and length of the throw is determined by the "weight" of the object (snowball or blue whale). Light objects like a snowball will smash onto the ice and disappear if you miss the opponent, medium objects like a seal will slide away on the ice after landing while the heavy objects like the blue whale will crash through the ice and leave a big hole in the ice cap.

However once again like in the rainforest duel, there is a price if one goes to excess. Too much increase in consumption will melt the polar cap and drown both players. In the rain forest mode, the winning strategy is to leave the right combination of consuming appliances *on*, (though not too much). In the North Pole duel the winning strategy is to very quickly turn the right appliances on and off. These two challenges were created to illustrate two opposing principles; the rainforest challenge illustrating the concept of continuous electricity consumption, while the North Pole challenge illustrates the concept of the power used of an appliance.

Winning a duel makes the players' avatar in the pile wear "the golden scarf of victory" until some other player wins it over in a new duel. However, these duels increases home electricity consumption and this will inevitably lead to a corresponding drop in ranking in the pile as well as the home garden being overgrown with thistles and become overcast with the CO2 cloud. However; *winning* a duel lead to a one hour long immunity against weed, which gave the natural system time to clean up the cloud and garden.

DISCUSSION

Reality expanded games like Power Explorer provides a number of unique opportunities in terms of persuasion and learning. First, they can transform ordinary environments into interesting and motivating landscapes by "keying up" everyday tasks into a frame of fun to drive attention to topics otherwise given little or no attention. If a mundane and otherwise filtered task such as conserving household electricity can be "keyed up" then it may be also possible that large amounts of overt messages such as tips can be omitted and still have the persuasive component and message intact.

Moreover, by applying this approach we need not to rely on simulated tasks in the game. We provide a real situated learning experience so problems of transfer becomes a non-issue and we have, in this game, joined the message and the game experience to minimize the effect of just learning the game and not the message [11, cf, 25].

Taking this as a point of departure, the Power Explorer game does not just that; it provides virtually instant individual feedback on appliance-level consumption. Hence, it is setting feedback in a frame of activity that may facilitate understanding of the power consumption of the home appliances.

Most often educational games come with in-game information or a structure for reflection and an educational context that aid users to interpret actions and information. However, our design approach can be said to be information-shallow since it provides no such in-game informative content, no in-game tips on how to succeed and no overt topical information and pointers. For example, many educational games provide tips and information with the game and managerial role-playing games are often followed by *debriefing sessions* where the experience is discussed. This information is used to foster reflection and joint understanding of events. However, our game relied entirely on shallow cues on own behaviors (in real time) and on basic social cues from peers. Hence, it can be seen to promote behavioral learning rather that cognitive learning. In Power Explorer, we intentionally left interpretation of actions and information to the gamer and this can seem to be a too narrow approach from a learning point of view. However, if we regard the *total social system and social expansion* of Power Explorer, we believe that actions and information can be interpreted in discussion with the family and peers outside the game. Let us now discuss how the social expansion of pervasive games can have a persuasive effect and to some extent also support reflection.

Power Explorer supports social expansion by necessitating communication with non-playing family members. The characteristic of the social expansion in Power Explorer is rather open and may not seem to be an obviously intended part of the game design at least when compared to games like Hot Potato or Insectopia. Power Explorer is designed for teenagers all living at home with families and sharing their households with parents and siblings. In previous studies with a similar game, considerable amount of family involvement was reported in the game and its tasks [3]. This included ordinary tasks such as players turning off appliances and lamps, reminding each other to conserve electricity, to more extensive measures like buying energy efficient lamps and even rebuilding the entire home heating system to make it more efficient. It seems that the family interactions that Power Explorer stimulates off-line can have a positive role in supporting reflection and debriefing.

To iterate; the debriefing and reflection sessions that Power Explorer may seem to lack, when viewed narrowly as a game system are actually very present when Power Explorer is viewed as a larger social interaction system. Therefore, a hypothesis one can state is that designers of educational pervasive games could omit traditional overt informative debriefing components of serious and educational games if that information instead is present in a social expansion particularly designed to fill that particular task. Hence, what becomes important is to form the conditions in the game so that it directs social formation and communication, for example, by choosing target groups appropriately and have a back-story that promotes interaction within the target groups. This opens up for pervasive-persuasive games as a means for bridging advergame design, serious game design, and viral marketing.

Power Explorer was field tested during 2008 and the results are undergoing analysis. Should the analysis show that our approach is too shallow in terms of information we may add parts to the game that will promote reflection on how energy and actions are intertwined. Particularly interesting would be to have situated information in the mobile when gamers are using a specific device.

CONCLUSION

In this paper, we have presented Power Explorer – a pervasive game that transforms the entire home into an engaging environment for learning about electricity. The approach allows gamers to get direct feedback on their own actions and on the electricity consumption of specific devices in the home. We suggest that pervasive games are ideally suited for persuasion and learning since that are able to transform ordinary mundane tasks into a frame of fun and drive attention to topics otherwise given little or no attention.

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