GAMIFYING ENERGY USER PROFILES

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Abstract

Smartege is an educational application which aims in educating users in the basics of electrical energy consumption and production and engage them in energy saving behavior, techniques and technologies. This is accomplished through the virtual, and eventually actual, management of residential and office buildings equipped with virtual devices and renewable energy sources, with energy specifications borrowed from actual commercial devices, towards the ultimate target of transforming the buildings into net Zero Energy Buildings. Ultimately, Smartege is a gamified application targeting the behavior modification of the users. Its content development follows the persuasive model and uses cognitive learning for the educational component and game mechanics for user motivation and triggering.

Keywords: Smartege, electricity user, behavior modification, cognitive model, gamification

Introduction

"We ought to be able to obtain the energy we need without consumption of material" affirmed Nicola Tesla in his visionary 1900 article (Tesla, 1900). Nowadays, his words are reverberating in the ever present struggle and challenge of energy resource control and management. The constantly increasing energy needs of our civilization and the emerging trends in electricity grids and markets converge in the need for demand side management, in which the end user has a pivotal role. However, the rapid and spectacular advances in technology along with poor design and funding, have left mass educational systems lagging behind and most of technology end users in awe, misinformed, alienated, and easy to manipulate.

Over the last decades, the deregulation of electricity markets and the Renewable Energy Sources (RES) technology have accelerated the emergence of distributed generation which together with advances in ICT technology led to the smart grid and demand side management paradigm as opposed to the conventional transmission grid and supply side management. In the new paradigm, the electricity user interacts in real-time with the provider, the grid and the markets. The electricity user behavior is therefore of fundamental importance in the future grid design and control as well as the EU energy targets (European Commission).

In dealing with these contemporary problems, the behavior modification approach is a powerful tool towards achieving technological literacy and shaping savvy electricity end users. Gamification is a promising educational methodology which can be used in behavioral modification. Gamification, coming from the field of digital media and marketing, first appeared in 2008 (Deterding et al., 2011), but became widely known in mid-2010. Figure 1 shows the position of gamification in the Gartner Hype cycle for 2014. From being at the end of 'innovation' triggering period (2012) and the peak of 'inflated expectations' (2013), it approaches the 'trough of disillusionment' (2014) and the 'plateau productivity' region faster than other emerging technologies.

In view of the current applications of gamification and the different interpretations that have been given, the definitions given vary and are directly related to the practices used. As a relatively new concept, it has been a controversial topic, especially concerning its application in the educational process, but has already been applied in many educational environments such as e-learning platforms, or as a teaching method, as well as in commercial applications in order to emotionally commit and engage users (Dominguez, et al, 2013; McCombs and Vakili, 2005; Lee and Hammer, 2011).

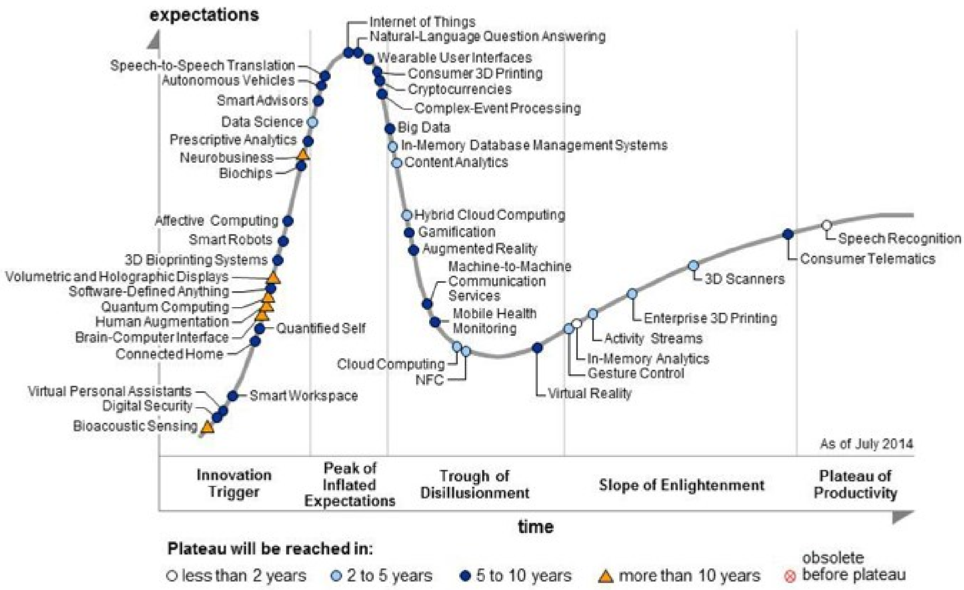

Figure 1 - Gartner Hype cycle for 2014

The gamified application proposed in this work does not intend to replace conventional teaching methods, nor be a commercial application for attracting users - clients. *Smartege* aims at combining the educational and commercial potential of gamification, in a new application development methodology that will lead the users, through education and increased involvement, to engage in activities and actions associated with electricity consumption, production and energy saving that they will perform on a daily basis. The ultimate goal is to engage the student/user and make them interact with a community in which inevitably they will negotiate with their cultural environment, traditions, history and customs and will be triggered to adjust their behavior and assume roles that will make them conquer the basic as well as overall concept of the subject in question.

Methodology

Gamification methodology is already applied in many educational environments such as e-learning platforms, or as a teaching method, but also in commercial applications in order to emotionally commit and engage users.

Although gamification classification literature is rather limited, the Behavior Change Gamification model, which was developed by Werbach and Hunter (Werbach, & Hunter, 2012) following a detailed analysis, aims at behavior transformation among a group of people. Behavior modification is also the ‘raison d’être’ of the persuasive technology as in Fogg’s behavior model – FBM (Fogg, B.J. 2009), Smartege is based on FBM according to which for a person to be convinced to change his behavior on an issue, he/she must satisfy three conditions: sufficient motivation, adequate capacity and efficient activation (Figure 1).

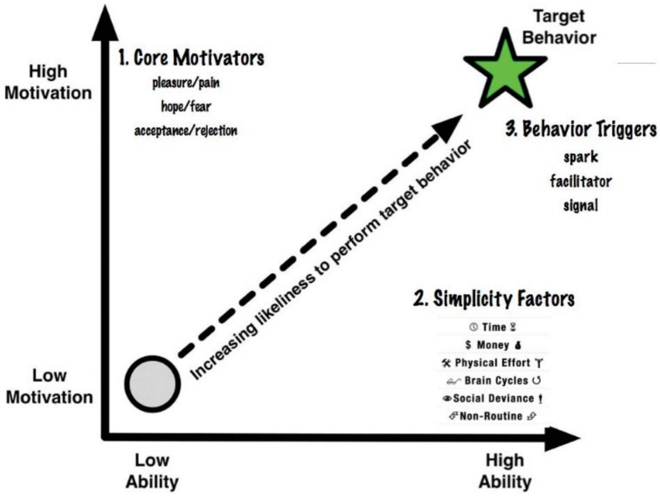

Figure 8 - The Fogg model is determined by three parameters: ability, motivation and activation (trigger) (Fogg, B.J. 2009)

According to FBM, the right time for intervention (activation) is when the point determined by the capacity (horizontal axis) and the motivation (vertical axis) of the individual, has a value greater than the value of the threshold needed for achieving the modification of behavior. In plain terms, it is the point when the person is at an appropriate level to accept a change and the only thing missing is the trigger that will activate it.

The capacity or 'ability' A of an individual (horizontal axis of Figure 1) is determined by the simplicity of the steps required to accomplish a task. An individual's ability is a function of six variables: money, m, time, t, physical effort, pe, mental effort, me, social deviance, sd, and non-routine, nr. At any given moment, the value of A is determined by the variable with the lowest value at the time of activation or triggering.

$$A = \min(m, t, pe, me, sd, nr) \quad (1)$$

Users' ability may be increased through education as the latter can significantly reduce the complexity involved in implementing behavioral change. For example, understanding the electricity bill, monitoring the electricity consumption of one's house or evaluating the energy profile of an electricity user, may become trivial tasks through proper education and familiarization with the process.

Therefore, in developing educational applications, we propose that the ability *A* is increased through education. The cognitive learning process, on which student centered learning is based, can be readily applied to gamified applications since it is a non-linear process and the student from passive knowledge receiver becomes an active partner in the process, employing actions, rational thinking, and interaction with others and the environment, in an effort to give meaning to the subject matter that he/she attempts to understand or conquer. Making meaning resolves the contradiction between what we know with certainty and what we think that others know on the one hand and what else we want to know or what we think we should know on the other (Wiltshire, 1990). In this content, knowledge acquisition is a user defined process. Cognitive learning follows the learning pyramid of six consecutive levels (Bloom & Krathwohl, 1956): know, understand, apply, analyze, evaluate, create. These six levels are used for the development of the educational content, the texts, the quizzes, the missions etc.

Engaging the user is of paramount importance in gamification. According to the flow model (Csikszentmihalyi, 2000), the indisputable model of most successful games, the user must be kept engaged, active, in 'flow state' through increase in skill or challenge (Figure 2). Game mechanics such as levels, badges, awards, counters, leaderboards *etc* are used in gamified applications to increase the users' engagement.

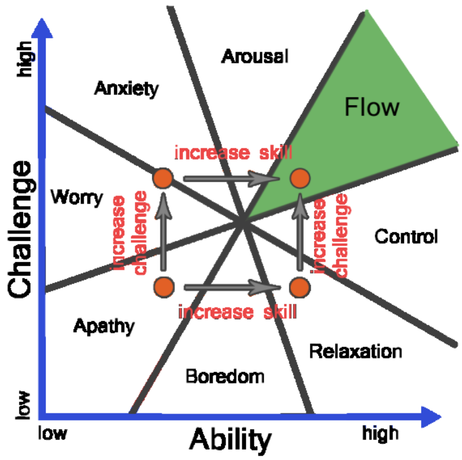

Figure 2 - The flow model (Schlutter, 2013)

We propose the use of such mechanics, in the spirit of the flow model, to increase user's motivation *M* (perpendicular axis of Figure 1) and to activate the user through appropriate triggering.

According to FBM, motivation revolves around three dipoles: a) the pleasure/pain dipole which has an immediate effect on the user, *e.g.*

gaining/losing points b) anticipated hope/fear has a long-term effect, *e.g.* moving towards/away from mastering a level c) social acceptance/rejection, *e.g.* score high/low on the leaderboard.

Triggers are categorized into: a) sparks for unmotivated individuals, *e.g.* messages triggering any of the three motivators described above b) facilitators for individuals of low ability, *e.g.* tips c) signals, for individuals of sufficient motivation and ability, *e.g.* notifications for the right timing.

Successful gamified learning should also observe other principles encountered in student-centered learning and/or gamification taxonomy (Ivetic & Petrovic, 2012), such as: feedback to the user must be ensured, *e.g.* in the form of counters, awards and notifications; the social dimension of the application should be served by both user-system and user-user interaction, *e.g.* in the form of messages, invitations, interactive content development; self-competition, *e.g.* in the form of achievements and competition against the other users, *e.g.* in the form of leaderboards, badges and use of social media, should be allowed; progression should be guaranteed through the transparent profiling of each user and the well-defined ultimate goal; graphics, colour and a narrative pertaining to real world situations should be used.

Smartege: not just another energy app

Most existing energy related games or gamified applications aim at raising ecological awareness at relatively young ages or allow the calculation of the energy consumption and CO2 emissions of appliances or devices. Certain applications, such as Electrocity, Power Matrix, Energy Ville, are adult strategy games employing energy related narratives. Smartege, on the other hand, aims not only at educating or entertaining but also modifying the behavior of adult electrical energy users. In this sense, potential *Smartege* users are all electricity users, regardless of age, race, sex, or economic background. Electricity users can be defined in the following broad categories with specific traits in their attitude towards the use of electrical energy: 1) domestic users who are responsible for paying the electricity bill of their residence 2) domestic users who are not responsible for paying the electricity bill of their residence, *e.g.* children financially dependent on their parents 3) users at the workplace or school who are not responsible for paying the electricity bill of the facility, *e.g.* employees in an office or students in a classroom 4) users at the workplace who are responsible for paying the electricity bill of the facility, *e.g.* building managers.

Smartege aims at enabling electricity users implement behavioral change and shift from being passive consumers in the conventional supply side management electricity grid and market paradigm to being active agents in the emerging demand side management grid and deregulated electricity markets. To accomplish that, *Smartege* relies heavily on its educational component intended to inform, educate and train users on the basics of electricity generation, distribution, consumption and saving.

Smartege is at the same time a game of:

✓ Simulation: because it simulates the consumption and production of electricity based on actual building requirements (residential or professional)

✓ Strategy: because it requires the user to set objectives and use optimally the tools and resources provided to him

✓ Learning & training: because there is material provided for the user's training to electricity issues through the application

✓ Quizzes: because many of the 'tasks' of the application are multiple choice questions based on the above material.

As explained in the previous section, the application's content addresses the cognitive, emotional and social area of the user (Constantos et al, 2014).

The cognitive content follows Bloom's taxonomy (Bloom et al, 1956) starting from simple definitions and tips and escalating to more complex explanations and tasks requiring deeper understanding and insight.

Feedback is continuously given in various forms: it can be points earned from accomplishing a variety of tasks (such as reading suggested material or answering a quiz), personalized comments on quiz results, badges rewarding successful completion of tasks and hints or tips on critical points during user's journey in the application.

The user may create his/her individual path to the top, selecting the specific objectives and activities offered.

The emotional content employs counters, badges (Figure 3) and awards to motivate the user and appropriate triggering based on the three dipole FBM motivators. The 'Smartege' user is expected to experience positive emotions such as curiosity, satisfaction, optimism as well as negative ones such as frustration and failure. Using game mechanics such as levels, rewards, leaderboards and missions we seek to transform the negative emotions to positive ones, such as succeeding, thus keeping the user in the 'flow' zone of the game. The 'Smartege' leaderboard is called 'Tesla's Followers' (Figure 4) and the user's ranking in it depends on the points earned though the progress of the game.

The social content includes missions and tasks intended to shape the social profile of the user, to allow the user to form an identity, by triggering him/her to invite friends, share knowledge and tips, perform actions like "like" or "comment". The leaderboard also appeals to the social area of the user since it displays the user's ranking relative to others'.

In a later version, the user will also be allowedto form synergies with other users and compete against other teams, thus emulating a competitive electricity market where the application moderator/coordinator has the role of the energy market regulation authority.

Finally, personalized communication is used for higher user involvement. For this, personalized data is needed which is accumulated through the user's actions as well as data entered by the user at various stages during the game as the user enriches his/her profile upon appropriate triggering.

Figure 3 Indicative Smartege badges: The Effective, the Newcomer, Gone... with the wind

Figure 4 TESLA's Followers: the Smartege leaderboard

The game mechanics, design and elements

The game has the following four counters:

a) 'Wallet points' which are accumulated when tasks and missions are accomplished; spent when new higher energy class or energy generating devices are acquired; lost when electricity is managed poorly

b) 'Electrical Energy counter' which emulates the energy meter recording net energy consumption and production in kWh

c) 'Green bar' which monitors the virtual building's energy class

d) ‘Comfort bar’ monitoring the level of comfort in the building, following the user’s actions, according to existing standards and design specifications (Constantos et al, 2014).

The user’s main quest is to maintain the values of three counters at levels that can ‘unlock’ the next level and progress in the game.

There are 4 levels in the application:

The first level is a tutorial which is intended to engage and activate the user in using the application. In this level, the user is introduced to the application’s environment and logic via a virtual ‘tour’. It provides the first impression to the user and, since it addresses most of the issues to be dealt with later on, is of high educational value and therefore mandatory.

Throughout the game, to accumulate points, the user is asked to answer a set of quizzes, the level of complexity and difficulty of which, is increasing with the user’s progress in the application. If the user fails at such a test he/she is prompted to read respective educational material available in the ‘library’ and take the test again. The user may proceed to the next level only if he/she has completed a full tour of the tutorial at least once.

Next, the user is called to select from the application’s “inventory” of typical home electrical and electronic appliances such as refrigerators, stoves, washing machines, dishwashers, TVs and computers, and position them in the 3D Flat he/she is going to manage.

This second level, the Flat (or Residential) level (Figure 5) is unlocked once the Tutorial Level is completed. When the user touches the appliances and devices that are selected and placed in the Flat, tips and in context information appears concerning their electrical characteristics and respective energy consumption. With the help of timely triggering and use of proper educational material, such as recommendations, explanations and definitions, the user is led to schedule the operation of the selected appliances in order to optimize the electricity consumption as well as the comfort level in the Flat. The user may increase the energy class of all buildings under his/her control by replacing existing appliances and devices with others of higher energy performance. This costs ‘Wallet points’ that are accumulated through the successful completion of tasks and missions.

The third level is the Office (or Professional) level (Figure 6) and concerns the energy management of an office complex. It is unlocked after the user has managed to reach A+ efficiency in Residence level, utilizing the expereince and knowledge gained so far. To attain the ultimate goal of net zero energy consumption buildings (nZEB), electricity microgeneration is necessary and therefore allowed from this level on. The user first learns to optimize the electricity use and consumption of all his/her buildings, residential or professional, and then is allowed to use ‘Wallet points’ to acquire and install electricity generation components. The concept of electricity production is a very important one in the game, since it allows the user to think of electricity as a resource and not simply as a costly comfort enabler. The user is also given access to educating material concerning electricity generation and storage devices, such as photovoltaics, wind turbines and batteries, as well as the relevant legal framework.

The next and last level is the 'My Home' level, through which the user can a) simulate the electricity use of an actual installation, *eg* his/her house b) with the acquisition of appropriate hardware, monitor the electricity use of the actual installation per appliance or electricity line, and have full control of it, setting operating points and allowing remote on/off. At this last level, the user is given the opportunity to relate what he/she has learned to the real world and implement change in his real life.

All the above mechanics are combined with progression metrics that calculate the user's progress in the game depending on the motivation of the phase in which he is. The Motivation Matrix (Figure 7) is one of the major instruments used in gamification to present the ways that attract users, encourage them to remain active in the application and attract new users in turn, through the social mechanisms of the game.

The users, depending on the phase of the motivation matrix are divided into the 4 main categories, such as guest, registered, social and devoted. Thus, the users of each main category depending on the actions that they are interested in doing are treated with a different approach though the motivation matrix (Constantos et al, 2015).

Figure 5 The 3D graphic user interface of the Flat level

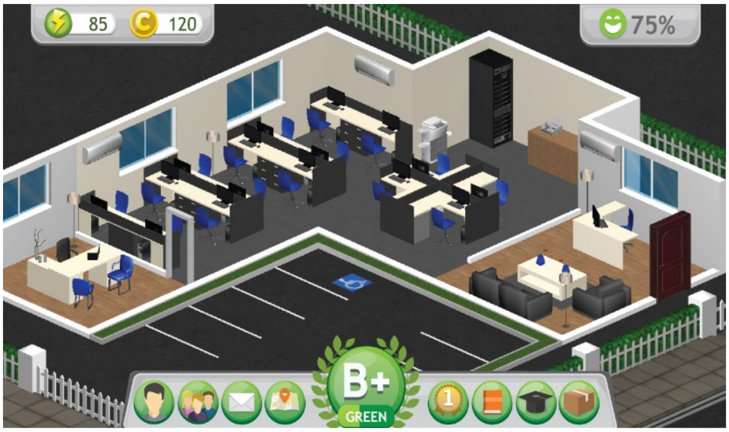

Figure 6 The 3D graphic user interface of the Office level

The following phases are discerned in the motivation matrix:

i. Acquisition: The phase of acquisition is one of the most important phases and its aim is to attract users to the game environment. The user's attraction is gained through an engaging browsing process that takes place in the tutorial level, where the user is introduced to the basics of energy conservation.

ii. Education: The task of training is active from the beginning of the tutorial to the end of the game. Training is conducted by providing trusted content sources and information to users. The tools we use in this section derive from the properly structured educational content, topics and tips that appear throughout the course of the implementation.

Figure 7 Smartege Motivation Matrix

iii. Attraction: In this phase an emotional connection is formed between the game users, who have by now spent some time in the game, and the application. Actions and tools serving this goal are the entertaining and functional content and the personalized features of the game.

iv. Involvement: This phase focuses on identifying and strengthening the leadership and collaborative nature of users. As the game progresses, users learn to trust their decisions and respond to the task of managing their building facilities more effectively and effortlessly.

v. Motivation: This phase is very important because the user is induced to form a network around him and attract new users to the game through the dissemination of information. Tools to achieve this are to prompt the use of social networks, the competitions between users and the diffusion and communication with people outside the world of the game.

vi. Conversion: In this phase we refer to the first objective of the game, which is to modify the electricity user's behavior. This is achieved with more specialized tools such as targeted content, targeted communication and targeted missions.

vii. Conservation: In this phase we try to maintain and strengthen the energy behavior of users, so that they carry the actions they learned in the game into the real world to the maximum extent possible and be able to monitor and control real energy profiles.

viii. Excitement: The last phase of the motivation matrix is based on the interest and passion of users for the game's environment and the ability to create emotional commitment that will make them come back again and again in the game. The tools to achieve this are the constant renewal of all type of content including quizzes, prompts to the user, as well as the game-user communication enabling the exploration of new ways and knowledge paths.

Conclusion

In this paper, we introduce a new methodology for the development of gamified educational applications for mobiles, tablets and PCs. It employs the persuasive technology for behavioral modification developing the application content in such a way as to increase the user's ability through education, increase the users' motivation to modify their behavior and trigger the users in the desired direction. The cognitive learning approach is used for the development of the educational content and game mechanics are used to trigger the user and increase user's motivation. *Smartege*, the pilot application presented here, targets the modification of users' behavior with respect to electricity use. In demand side management grids and deregulated electricity markets, the user must be trained to be an active participant rather than a passive consumer. *Smartege*, allows the users to shape their own path towards learning how to understand, monitor, control and shape their energy profiles through the virtual management of a residential and an office building that must be transformed into net Zero Energy Buildings through optimum consumption management and small scale production using reneawable energy sources. Furthermore, *Smartege* offers the possibility to manage an actual installation, such as the user's house, via appropriate metering and control hardware that communicates with the application's environment.

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