Steps to Design a Household Energy Game

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Abstract. Research where gamification is used to influence household energy consumption is an emerging field. This paper reviews the design of games that aim to influence household energy consumption. The designs of ten games are analyzed. From this review, suggestions for the design of a new game have been identified, such as presence of a strong storyline, real live missions, customized game characters, monitoring the electricity meter, etc. Based on this comparative analysis, a new game focused on reducing energy consumption has been designed and its prototype is described and will be demonstrated at the conference. In the next stage of iterative design, end-users will be involved by means of focus groups. This considerate user-centered design process allows us to build a serious game that is effective in reducing household energy consumption.

1 Introduction

Gamification research has shown that the integration of serious games into real life could have positive effects on attitude and behavior [9]. Game design can be a valuable strategy for making non-game products, services, or applications, more enjoyable, motivating, and/or engaging the user [6]. The steps in designing a household energy game, which is presented in this paper, are part of a larger research project that will give insight into what the influence of playing in the real world is on sustainable behavior in the long term, and on attitudes towards sustainability. We focus specifically on energy consumption in households by means of electricity usage. The target is to contribute to the stimulation of individual sustainable behavior by studying how gamification can be a positive incentive for people to change their behavior regarding energy use at home. It aims to study whether this transfer from game play to real life behavior has a long-term character [9]. For this research project a game was designed that is to be used as a research instrument that will allow us to investigate different factors such as feedback, personal relevance and social interaction and that could strengthen the change in attitude and behavior. It is generally recommended that potential users of the game be involved in the development process [5]. This will be done in the next phase by means of focus groups. However, first the design of the game is established (step 1) by analyzing the designs of existing games that have a similar purpose. This is achieved by identifying a number of dimensions in the literature. Our assumption is that when the analysis (step 1) is done properly and potential users are

involved in the design process (step 2), then this considerate user-centered game design will lead to a high quality game that is effective in reducing household energy consumption. We will first identify games that have similar, or at least partially similar, goals to the future game developed here (Sect. 2). The design of these games is analyzed with the dimensions/characteristics identified (Sect. 3). The optimum implementation of characteristics, and what might be lacking, will become clear from the considerate analysis. Based on this, suggestions are made (Sect. 4) for the final design of the game consistent with the research objectives. Finally, a description of our prototype will be presented.

2 Overview of Method to Analyze Energy Games

2.1 Goals

We have formulated six goals based on the requirements of the design of the game. The first goal is that the game makes players aware of sustainability issues concerning energy use at home. The game raises awareness. The second goal is the transfer of information about energy consumption so that players acquire more knowledge. The third goal is that players will be influenced by the game to change their behavior concerning energy consumption in real life. The fourth goal is that behavior in real life is integrated into the game by monitoring behavior in real life and using this information in the game progression. The fifth goal is that the game is played over a relatively long period of time and has several sessions. The sixth and final goal is that the game has a compelling and complex storyline that is able to engage players. A storyline in a game can be engaging because it stimulates our emotions [14]. A complex storyline includes a setting where game characters have to achieve goals and face multiple obstacles in reaching them [18].

2.2 Energy Games

Our game design is focused on energy use at home, specifically where personal behavior is involved. Games that also have this focus were chosen based on the above six goals. In February 2015, searches were performed in scientific databases and with the aid of public search engines. In these databases eight games were found that had been used as a research instrument with similarities to our research. These eight games are analyzed in this paper. The output of public search engines also suggested many games that are used for education and entertainment (but not for research) purposes. Unfortunately, only two additional games (*Joulebug* and *2020Energy*) are interesting to analyse because they have some similarities with our goals. Other games that came out of the search are not useful because they do not have a connection with real life energy consumption behavior and/or are too simple. The ten selected games are presented in the table of Appendix 1.

2.3   Characteristics of Game Design Analysis

Nineteen characteristics that are inspired by Prensky [14], Adams [1] and Schell [17] are distinguished to analyse the ten games. These characteristics are described in Table 1 in Appendix 1. The characteristics are clustered into five topics. The first topic is identification. A game is introduced by mentioning four general characteristics: (1) the year the game was released, (2) the research group/owner, (3) the purpose of the game (research, education or entertainment) and (4) the profile of the players. The second topic is Game Play. The game itself is described by mentioning (5) the description of the game type, (6) quality of the storyline, (7) the levels and progression (chronologic stages in difficulty) and (8) the representation of game characters. The third topic is Game Design. The presentation of the game and features are discussed by describing (9) the world (real life and/or in-game) where missions are accomplished, (10) the quantity of missions, (11) the possibility to customize, (12) feedback and rewards, (13) competition (high scores by oneself and/or competing against other players), (14) the quality of the graphic design, (15) real world effect (effect of behavior in the real world on progression in the game), (16) monitoring the electricity meter and (17) the duration of the game. The fourth topic is (18) the Technical Architecture that explains the technical design of the system. The fifth and final topic is Research Method. The research procedures of the eight games that are used as a research instrument are described, and (19) the kind of effects that are measured is mentioned.

3   Evaluation of the Implementation of Game Characteristics

The ten games that are selected have been analyzed and compared to each other by means of these nineteen characteristics. An overview of the results of this analysis is presented in Table 1 of Appendix 1. In the order of the five topics, the best implementations of characteristics and what is overall lacking are discussed. At the same time suggestions for the new design are made.

Topic 1. Identification. Characteristics Year (Char 1), Research group/Owner (Char 2) and Purpose (Char 3) are not discussed because they are only used to identify games. It is interesting to look closer at Player's profile (Char 4). In six games the game is played in family households, which include teenagers. There are good arguments to use family households as a study population. Family members all consume energy that can only be measured from an electricity meter, so it is reasonable and preferable that the whole family is involved in playing.

Topic 2. Game Play. Six different game types (Char 5) are mentioned. Two games are Simulation and Role-playing games, two games are Adventure and Role-playing games, two games are FarmVille like games and two games are Multiplayer games. *EnergyLife* is the only Eco-feedback game and *Joulebug* is the only Social mobile game. Implementing simulations can help players to prepare for real life missions. Role-playing can engage players more and adventure elements can be used for the storyline. Altogether, the games mainly focus on providing feedback on energy consumption. There are no games with a compelling and complex storyline (Char 6).

In general the games are not story-focused and miss the opportunity to enhance gameplay [17]. The games *Power Explorer* and *EnergyLife* have the best level and progression structure (Char 7). The strength of the game *Power Explorer* is the combination of normal gameplay and duels. *EnergyLife* has three levels with different activities. None of the games has levels that become more difficult during playing, and no game has the alignment of a compelling storyline and difficulty in playing. For our game it is preferable that a storyline will be implemented and missions become more complex when progression in the game is made. In seven games, game characters (Char 8) are used in the design. In the games *The Power House*, *EcoIsland* and *Powerhouse* the characters are family members that have some similarities with the characteristics of the players. Only in *EcoIsland* it is possible to "customize" the player's avatar. This feature should be implemented in the design of our game because it establishes a stronger connection between the game and reality [17].

Topic 3. Game Design. Eight games have real life (Char 9) energy saving missions. The game *Power House* has a strong combination by using both real life and in-game missions. It is preferable that in the design our game missions have to be carried out in real life. Using in-game missions to prepare players for real life missions is an option that should be considered. From six games we have no information about the quantity of missions (Char 10) available. The game *Power House* has, with ten missions, the most. In the games *EcoIsland* and *EnergyLife* customization (Char 11) is to some extent possible. In *EcoIsland* the avatars can be customized, and in *EnergyLife* a player can add two electrical devices to the five that are standard monitored. The customization of avatars and the addition of electrical appliances in the game is preferable, because it can have a positive influence on the involvement of the players. Seven of the ten games provide maximum feedback (Char 12) by means of points, badges/achievements and overviews of energy used or saved. All items should be implemented in our game design. In nine games players compete (Char 13) against themselves and others. Both should be implemented in our game. Only in the game *2020Energy* do players not compete against each other. Four games have high quality graphics (Char 14). The game *Power House* has the best graphics and can be used as an example for the development of the game for our research project. In seven games the player's behavior in the real world has a very strong effect on the game (Char 15). In our game it should be strong because real life missions will be implemented. In eight games the energy consumption is monitored (Char 16). This should be implemented in our game. Information that is obtained from continuously monitoring the energy consumption can be used to make progression in the gameplay. In the games *EnergyLife* and *Energy Chickens* electrical devices are monitored separately. This could be considered for implementation in our game if more specific feedback from individual appliances has to be provided. The duration of the games (Char 17) varies between a session to twenty-seven weeks. Four games are played for a month or more. Because we want to look at the long-term effects on behavior and attitude after playing the game it is plausible that the duration of our game should be extensive.

Topic 4. Technical Architecture. (Char 18) In six games the Technical Architecture is very advanced. The energy consumption is monitored and sometimes directly used in the game. For the game design of our project it is preferable that a real time connection

between the electricity meter and game server is accomplished by using a datalogger with an Internet connection that is connected to the electricity meter in a household that has a WiFi network. The data of energy consumption will be sent to a database of a server. The option to cooperate with a network operator instead of using a datalogger is not recommended because the data transfer can be delayed. It is preferable that the game is basically an Internet page that is uploaded by a device (e.g. tablet) when the player logs in via an Internet browser.

Topic 5. Research Method. (Char 19) Knowledge, Attitude and Engagement are measured by means of questionnaires outside the game play. These questionnaires should be filled in before and after playing. Knowledge is also often measured with in-game quizzes and engagement can be measured by monitoring player's behavior during playing. These two options should be considered in our game design. Energy usage is measured by monitoring the energy meter. To set a good baseline for giving feedback about average energy consumption during playing, the energy consumption should be monitored before the game starts.

4 Conclusion

4.1 Meeting the Goals

First we will indicate to what extent the analysed games met the goals that are described in Sect. 2.1. The first goal is to make players aware of sustainability issues concerning energy use at home. To some degree almost all analysed games, except *Energy Chickens*, do this. The games *EcoIsland*, *Joulebug* and *2020Energy* also focus on energy use out of home. *Energy Chickens* is played in a work environment instead of a home but it is very likely that these players will also be more aware of energy use at home. The second goal is the transfer of information about energy consumption so that players acquire more knowledge. All analysed games do this. The games *Joulebug* and *2020Energy* also focus on other sustainability issues. The third goal is that players will be influenced by the game to change their behavior concerning energy consumption in real life. All analysed games do this more or less. This effect seems to be more likely when the electricity meter is part of the technical architecture. Because of this the games *The Power House* and *2020Energy* will only have indirect influence, as the energy usage is not measured. The games *The Power House* and *2020Energy* do not meet the fourth goal because the electricity meter is not connected to the game. Only the games *The Power House* and *2020Energy* do not meet the fifth goal that the game is played over a long period of time and has several sessions. The sixth goal is to have a compelling and complex storyline. Six games have a storyline, but unfortunately it is in all cases a very simple one. From this evaluation of goals that are met we conclude that the games *The Power House* and *2020Energy* do not meet many goals, other games do meet most of the goals and none of the games has strong storylines.

4.2 Required Design Features

From Sect. 3 and Appendix 1 we derive the following recommendations on design features to be implemented in the design of our game. Players should be all members of a household and play together. The game should have a compelling storyline and players have to accomplish real life missions that are provided by the game. Knowledge should be provided by questions in in-game quizzes. Missions should become more difficult over time and have a connection with the development of the storyline. The duration of a mission should depend on its intensiveness and will vary between one to three days. Depending on the quantity of missions the game should take at least more than a month to play. The game characters/avatars should have similarities with the players (customization). The world/setting of the game should have similarities with a household. Therefore specific devices of households should be present in the game world. Feedback should be provided by means of earned points, badges/ achievements and overviews of energy used and saved. Players should be stimulated to achieve high scores and should be in competition with other households. The game should provide readings from the electricity meter and/or if technically possible readings from household appliances.

4.3 Final Design Prototype of the Game *The Power Saver*

In order of the five topics, we describe the final design of the prototype of our game '*The Power Saver*'.

Topic 1. Identification. The game will be played in a household whereof in principle the whole family is involved (Char 4).

Topic 2. Game Play. It is an Eco-feedback, Multiplayer, Roleplaying and Point and Click Adventure game (Char 5). The game starts with an introduction of the story (Char 6). A family arrives at a dilapidated country house where something terrible has happened. The house used to be a peaceful place but that has changed dramatically caused by a failed experiment of a professor. The family enters the main hall of the house that contains several doors (Fig. 1a). Behind each door a room is situated where a game character in the form of a confused electrical device is placed. A ferret (former pet of the professor) called Kyoto guides the family in the game. Every week the family is asked to enter a preselected room. Before the door opens a quiz has to be played. A quiz contains questions that will prepare players for the missions that are occurring in that specific room. When the family enters the room a character in the form of a device that is in a confused state is shown (Fig. 1b). The family has to accomplish two missions to help the device character to get in a happy state (Fig. 1c). During the game the missions are getting more difficult (Char 7). Avatars of the family members are the central characters of the game (Char 8) (Fig. 1d).

Topic 3. Game Design. All missions (e.g. washing clothes on low temperatures) take place in the real world (Char 9). The game has fifteen missions, ten quizzes and an end-battle (Char 10). It will take two to three days to complete a mission. The missions are developed by the use of general energy saving measures. The family composition in
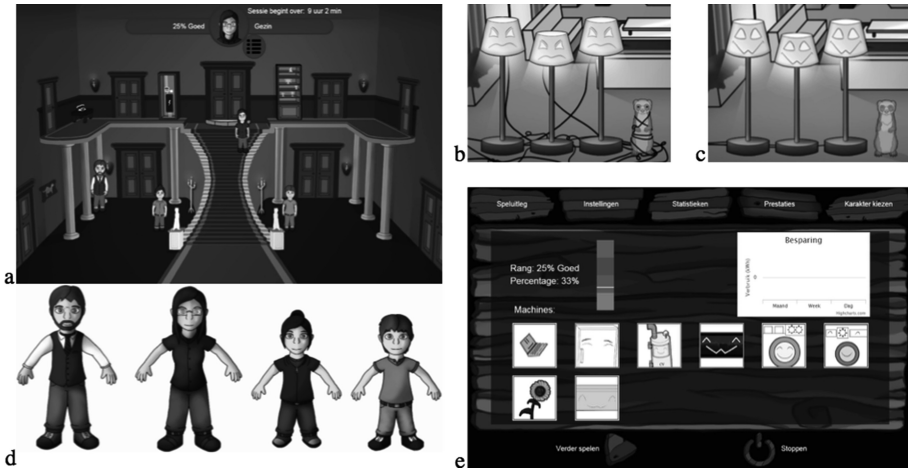
Fig. 1. Screenshots prototype game *The Power Saver*

the game is customised to the household (Char 11). In the prototype it is not possible to add specific devices from the household, though all general household devices are incorporated in the game. The player is getting feedback during playing (Char 12) (Fig. 1e). The energy use and savings are displayed in kWh and money. Also the savings per year is provided. A graph is used to give the player an overview of the energy use and a meter is developed to stimulate the energy saving behavior. The result of the quizzes is shown in a bar. The achievement of a completed mission is displayed with a badge of the happy device character corresponding with that mission. There is no competition (Char 13) with other households implemented in this prototype. In future versions this will be added. The quality of the graphic design (Char 14) is adequate (Fig. 1) and the navigation by the player is done by point and click on the screen. The player's behavior in the real world has a very strong effect on the game (Char 15), because real life behavior influences progress by means of completing missions and feedback of real life energy consumption that is monitored (Char 16) and presented continuously. The total period of playing the game is seven and a half weeks (Char 17).

Topic 4. Technical Architecture. An overview of the proposed technical architecture is shown in Fig. 2 (Char 18). A real time connection between the electricity meter and individual appliances and game server is accomplished by dataloggers with an Internet connection. The households have a WiFi network. The data of energy consumption will be sent to a database of a server at Utrecht University. The game is an Internet page that is uploaded by a device (e.g. tablet) when the player logs in via its Internet browser.

Topic 5. Research Method. Energy consumption is monitored a month before the game starts to set a good baseline of average energy consumption. All four effects of playing the game are measured (Char 19). Knowledge will be measured by using questionnaires before and after playing and the scores of quizzes in the game. Attitude will also be measured by using questionnaires before and after playing. Energy usage
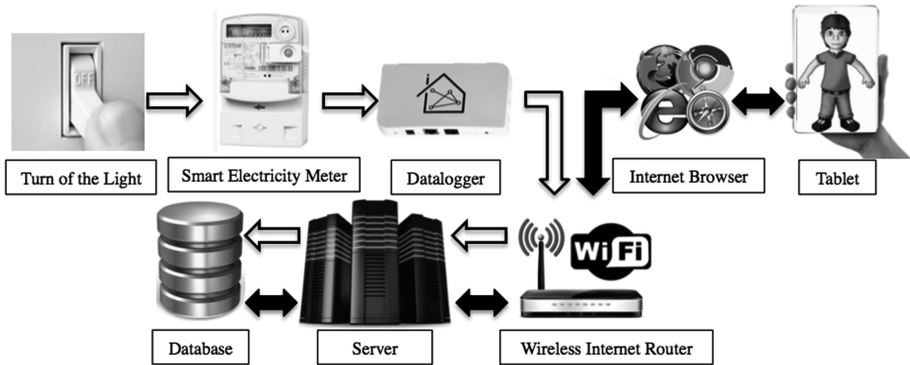
Fig. 2. Final design technical architecture of *The Power Saver*

will constantly be monitored from the energy meter. Engagement will be measured by using questionnaires before and after playing, by monitoring player's behavior during playing and monitoring how often the player logs in and what he/she is exactly doing for how long.

5 Discussion

In this review it is not yet taken into account what exactly the empirical effects are concerning behavior, knowledge and attitude, of design as a whole and/or of the individual characteristics. This can be equally important for making choices in the final design. A future paper will address this issue. We strive to develop a game based on user-centered design [5]. The presented prototype is not yet user-centered but just the outcome of the considerate part (step 1) of the game development process which consists of the analysis of the ten games, formulated goals and the skills of the developers. The next step is to involve the potential players in the design process. Eight families in the form of focus groups will evaluate this prototype. Four families evaluate the missions, quizzes, storyline and look and feel of the game. When adjustments in the game design have been made, the redesigned game is entirely played by the other four families. Based on this user study final adjustments are made and the game developed with this considerate user-centered design will be subsequently used in the research project. In our project we focus on a "value added" approach [12] where the effects of the features feedback, personal relevance (by means of customized avatars and addition of electrical appliances) and social interaction (by means of competition) on knowledge, attitude and behavior are examined. The technical developers have made it possible to add or remove these features in the prototype for future experiments. For example, feedback can be adjusted and competition between families can be added. However, we start our project with a "media comparison" approach [12] where the effect of the game is contrasted with another medium. During this experiment one group will play our game and a control group will receive the same information in the form of an intensive sustainability course that will take as long as the game and results will be compared.

Appendix 1

See Table 1.

Table 1. Overview ten energy games

Topic	Characteristic	1 The Power House [2]	2 Power Agent [3][9]	3 EcoIsland [11]	4 Power Explorer [4][10]	5 Agents Against Power Waste [19]
Identification	1 Year	2006	2007	2008	2008	2010
	2 Research group/ Owner	Bang et al.	Bang et al.	Kimura et al.	Bang et al.	Svahn, M.
	3 Purpose	Research	Research	Research	Research	Research
	4 Players profile	Teenagers	Teenagers in households	Households incl. teenagers	Teenagers in households	Households incl. teenagers
Game Play	5 Game type	Simulation & Role-playing	Adventure & Role-playing	FarmVille like	Multiplayer	Adventure & Role-playing
	6 Storyline*	+	+	--	+	+
	7 Levels & Progress*	+	+	--	++	?
	8 Game Characters *	+	+	+	+	--
Game Design	9 Mission world	In-game	Real life	Real life	Real life	Real life
	10 Mission quantity	?	7	?	2 duels	?
	11 Personification/ Customization	No	No	Yes	No	No
	12 Feedback and Rewards**	Combi.	Combi.	Combi.	Combi.	?
	13 Competition (Oneself/Other)	O/O	O/O	O/O	O/O	O/O
	14 Graphic Design*	-	+	-	++	-
	15 Real world effect*	--	++	++	++	++
	16 Monitoring elec. meter	No	Yes	Yes	Yes	Yes
	17 Duration	1 Session	1W	3W	1W	4W
	18 Technical Architecture*	-	++	+	++	++
Research Method	19 Measured Effect:					
	- Knowledge	?	Yes	No	Yes	Yes
	- Attitude	Yes	Yes	Yes	Yes	Yes
	- Energy usage	No	Yes	Yes	Yes	Yes
	- Engagement	Yes	Yes	No	Yes	Yes

Topic	Characteristic	6 EnergyLife [7][8]	7 Joulebug	8 Power House [15][16]	9 2020 Energy	10 Energy Chickens [13]
Identification	1 Year	2011	2011	2011	2012	2014
	2 Research group/ Owner	Gamberine et al.	Joulebug	Reeves et al.	ENERGY-BITS	Orlanda et al.
	3 Purpose	Research	Entertainment	Research	Education	Research
	4 Players profile	Adults in households	Trendy young adults	Adults in households	Teenagers	Office workers
Game Play	5 Game type	Eco-feedback	Social mobile	Multiplayer	Simulation & Role-playing	FarmVille like
	6 Storyline*	--	--	+	+	--
	7 Levels & Progress*	++	--	+	-	-
	8 Game Characters *	--	--	+	+	+
Game Design	9 Mission world	Real life	Real life	In-game & Real life	In-game	Real life
	10 Mission quantity	?	?	10 sessions	9	?
	11 Personification/ Customization	Yes	No	No	No	No
	12 Feedback and Rewards**	Combi.	Combi.	Combi.	Points & Ach.	Combi.
	13 Competition (Oneself/Other)	O/O	O/O	O/O	Oneself	O/O
	14 Graphic Design*	+	++	++	++	+
	15 Real world effect*	++	++	-	--	++
	16 Monitoring elec. meter	Yes	Yes	Yes	No	Yes
	17 Duration	16W	Infinite	2,5W	1 Session	27W
	18 Technical Architecture*	++	++	+	-	++
Research Method	19 Measured Effect:					
	- Knowledge	Yes	No	Yes	Yes	Yes
	- Attitude	Yes	No	?	Yes	Yes
	- Energy usage	Yes	Yes	Yes	Yes	Yes
	- Engagement	Yes	No	?	Yes	Yes

* --/-/+/++   ** Points, Badges/Achievements, Energy use/savings or a Combination (Combi.)

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