A LUDIC LEARNING ENVIRONMENT TO TEACH EFFICIENCY ENERGY CONCEPTS

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Abstract — Currently the non-judicious use of energy resources has a tremendous impact on the global economy and environment. Most importantly, professionals (e.g., architects, engineers, and designers) and citizens who are concerned about the importance of efficient energy use can dramatically change this impact or what may be referred to as an increasing energy consumption nightmare. University courses can (and do) include topics about this subject but unfortunately this excludes participation from some segments of society. Thus, it is necessary to implement mechanisms to disseminate energy efficient concepts to the general public. An engaging software, like a computer game accessed through the internet, can provide interactive tools ("edutainment") to transmit energy efficient concepts to professionals as well as the many others. The computer game discussed herein, known as the EEHouse, is a ludic learning environment intended to teach energy efficient concepts to such persons.

Index Terms — Energy Efficiency, Ludic Teaching Environments, Computer Games.

INTRODUCTION

Currently the non-judicious use of energy resources has a tremendous impact on the global economy and environment [1]. Most importantly, professionals (e.g., architects, engineers, and designers) and citizens who are concerned about the importance of efficient energy use can dramatically change this impact or what may be referred to as an increasing energy consumption nightmare. University courses can (and do) include topics about this subject but unfortunately this excludes participation from some segments of society. Thus, it is necessary to implement mechanisms to disseminate energy efficient concepts to the general public.

Attempts to increase energy efficiency awareness through public campaigns have resulted in limited effects because it is typically difficult for the public to focus solely on one topic (e.g., energy efficiency) over a long time period. As well, campaign budgets for such initiatives are often limited. An engaging software, like a computer game accessed through the internet, can provide interactive tools ("edutainment") to transmit energy efficient concepts to professionals as well as many others. The computer game discussed herein, known as the EEHouse, is a ludic learning environment intended to teach energy efficient concepts to such persons [2], [3], [4]. The EEHouse scenario presents a building with six apartments. Players control a mechanism to offer limited amounts of energy to a variety of typical building residents.

GAME OVERALL CONCEPTION

Recently the intense use of the Earth's resources and increasing pollution has caused drastic changes in global weather patterns. Many rivers, for example, have shown decreases in overall water levels. The conditions have gotten so critical that governments have created laws establishing criteria for when to use water and energy resources.

Buildings and houses have consequently been forced to consume pre-defined quotas of electrical energy and water. Electrical generators installed in many buildings use gas to generate energy. The gas containers are typically replaced in a defined period of time. Each manager of these buildings (*syndic or superintendent*) is thus the gatekeeper who must control the gas consumption in order to avoid energy misuse and periods without energy. If the gas supply is depleted before the replacement period, the building could theoretically run out of energy.

Moreover, the electrical generator has a maximum power output and it can't generate energy in peak periods over an extended period of time without becoming damaged. Thus, it is not sensible to intensively use the remaining gas in the containers in periods close to replacement for fear of not having any gas at all.

In this game, the user assumes the obligations and role of the syndic and must organize the life of the residents in a way that it is possible to consume energy in an efficient manner so that it doesn't result in unnecessary traumas in the occupants' lives. If the personal trauma is significant, the syndic loses points in the satisfaction factor/category. If this factor value decreases below a minimum limit, the syndic is fired.

The game's first version allows playability only through the syndic. He decides if a resident can use energy to execute a specific activity based upon a priority activity list. The list is dynamic; it can change in function with varying external factors, such as weather, length of day, profession of the residents, as well as health and emotional conditions.

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The game development platform software is Macromedia Flash [5] as the game has a 2D interface and, mainly, this software is very popular and allows for Web publishing.

GAME SCENARIO

The conception of the scene and the dynamics of the game were based on the Neuro animation [6] popularized by the Italian animation producer Bruno Bozzetto. Through simple traces and animations, Neuro displays the problems that develop amongst the apartment's residents. It should be noted that Neuro also uses extremely simple figures to animate the action of the building residents, all of which can therefore be more easily operated within the game.

The EEhouse scenario has the following elements installed in Neuro (see Figure 1):

a) Building: The building image is a transverse section through three floors of the apartment building, each floor containing two apartments. The elevator equally splits the left side dwellings from the right side.

b) Surrounding environment: The surrounding environment, which includes the building, has the ability to show periods of the day (morning, afternoon, evening, night), various weather conditions (sunny, cloudy, rainy, snowy) and a variety of temperatures (very hot, hot, pleasant, cold, very cold).

An overall view of the scenario is only exhibited in the introduction to the game. To allow more efficient game-user interaction, the interface shows the building in a simplified form, focusing on the apartments' interiors (see Figure 4).

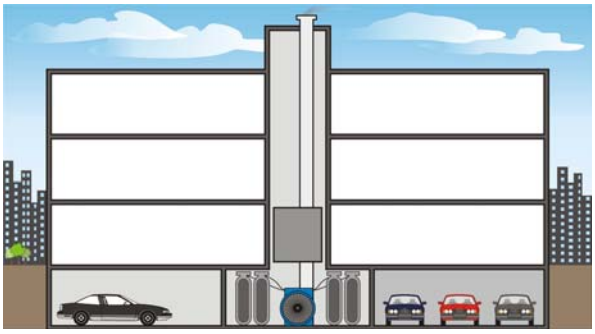

FIGURE 1
BUILDING OVERALL VIEW.

CHARACTERS

The game characters are divided into two categories: syndic and residents. The syndic is the user/avatar in the game. The residents have the function/ability to ask the syndic permission to execute actions that will consume energy. Thus the game not only addresses energy efficient usage but also incorporates social interaction and the consequences involved in social decision making.

The game characters were defined and developed based on the premise that the residents' energy needs vary according to their individual profiles. As well, as the interface reserves a section of the game screen to show the residents, it was considered that fewer characters improve the interface legibility and allow the players to focus more on the residents' profiles and, consequently, their needs. For example, a couple with a baby has many needs, but a single mother with a baby forces the woman's actions to be focused on child care. Along similar lines, a selection was made to include an old man (rather than an elderly couple) and a divorced father with his young boy.

The following residents will occupy the six apartments in the building: a) single mother with baby, b) old man, c) female student enrolled in an undergraduate course, d) divorced father with his teenage son, e) middle age business man, and f) newly married couple.

Figure 2 shows a draft of the syndic and the old man. Figure 3 indicates how the old man will be presented in the revised screen. Notice the simplification of the detail within the newer figures.

FIGURE 2
SYNDIC AND OLD MAN DRAFT.

FIGURE 3
SYNDIC AND OLD MAN APPEARANCE IN THE INTERFACE.

GAME INTERFACE

The game interface is still in development stages but some design principles have been adopted and created [7]:

a. Having Neuro as an inspirational source, the main target of this version of the game is the animation process simplification without diminishing the ludic and the attractiveness factors of the interface.
b. The game environment is 2D. The images will consequently have less realistic refinement and detail but great expressiveness (see Figure 3).
c. It is not entirely necessary that the syndic figure appear because his main activity is to allow or not all resident actions. However, there is a satisfaction factor associated with him (with respect to his decision making), which can be shown in the syndic's facial expressions. This approach increases the interface attractiveness. As the syndic (user-avatar) appears in the game, the interface can therefore be classified as third-person singular.
d. The interface is divided into three main areas:
    1. The scene area (where the building is located and the events occur),
    2. The area of exhibition of the different parameters that compose the game (e.g. level of the fuel, satisfaction of the inhabitants, etc) and
    3. An information area (to record the occurrence of a random event, acknowledgment of some problem, etc).

    Figure 4 shows a preliminary sketch of the interface.
e. The game audio will be composed of music and sonorous effects related to the characters' activities as well as the performance of the players of the game. Audio constraints will be based in psico-acoustics concepts and the technological resources available.

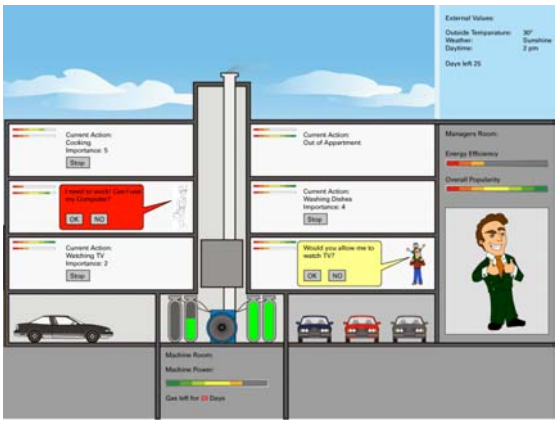

FIGURE 4
INTERFACE PRELIMINARY DRAFT.

GAME LOGIC AND DATA STRUCTURE

The game will operate according to the following:

The characters will be allowed to perform all of the set or a subset of the actions described in the table Allowed Actions, which correlates index and action. The following definitions describe the possible actions: 1-Take a shower; 2-Cook; 3-Wash the dishes; 4-Watch TV; 5-Turn on the lights; 6-Use the computer; 7-Use the vacuum cleaner; 8-Listen to music; 9-Take the elevator; 10-Bath the Baby; 11-Play the videogame; 12-Wash the clothes; 13-Dry the clothes; 14-Turn on the fan; 15-Turn on the heating; 16-Dry one's hair. (It should be noted that many other actions could be added to the table).

An action priority vector is associated with each character. This vector is indexed by the action indices. The values in the table Priority (see Table 1) define the following priorities: 0 – the action is not performed by the character; 1 – the action has very low priority; 2 – the action has low priority; 3 – the action has medium priority; 4 – the action has high priority; 5 – the action has very high priority. The table Priority has the following format:

TABLE 1 - PRIORITY
PRIORITY OF EACH ACTION ASSOCIATED TO EACH CHARACTER.

Action	**Character1**	**Character2**	**….**
1	5	3	….
2	0	1	….
…	…	…	….
N	4	2	….

The initial definition of external factors considers the following: period of the day (morning, afternoon, evening, night), weather conditions (sunny, cloudy, rainy, snowy) and temperature variance (very hot, heat, pleasant, cold, very cold).

Table 2 below, an example of a portion of the Table Priority Offset, illustrates the increases and decreases in the priority values according to the external factors. There is no Pleasant-Weather or Afternoon-Period column because the priority values were defined considering these conditions. Notice that these values can be changed. (This is a draft-proof of concept- only).

TABLE 2 - PRIORITYOFFSET
(IN) OR (DE)CREMENTS IN THE PRIORITY VALUES ACCORDING TO THE EXTERNAL FACTORS .

Action Index	**Morning**	**Evening**	**Night**
01 (Take a shower)	+1	+1	-1
02 (Cook)	+2	+2	-1
03 (Wash the dishes)	+1	+1	0
04 (Watch the TV)	0	+1	0
05 (Turn on the lights)	0	+1	+1
06 (Use the computer)	0	0	+1
07 (Vacuum cleaner)	+1	0	0
08 (Listen music)	0	0	-1

...	...	...	...

Other externals factors are associated with each character. For instance, if the businessman is required to finish an important project, this can mean that he needs to use the computer more often. In this instance, the priority associated with the computer use in his priority table can be increased. If a baby gets diarrhea, this can mean that her mother needs to wash clothes more often. In this case, the priority value associated with "wash the clothes" in the mother priority values can be increased.

The activities are divided into hierarchical groups (5-Very High, 4-High, 3-Average, 2-Low, 1-Very Low) according to the energy they consume. This classification is carried through in the form of energy consumption calculations, as sketched in table 3, called Energy Consumption.

GAME DYNAMICS

The player wins the game if the syndic completes one definitive period of time (still not defined) in the following conditions:

a. the minimum limit of the building inhabitants' satisfaction level was not exceeded,
b. there is still gas in the gas containers until next replacement or
c. the electrical generator was not damaged because of working in a peak demand time over a long time period.

TABLE 3
ENERGY CONSUMPTION OF SOME ALLOWED ACTIVITIES.

Period Monday to Friday	Energy Type	W	m³/h
Refrigerator	Electric	300	0,003
Cook	Thermal	3000	0,099
Bath	Thermal	5000	0,165
Dry hair	Electric	1500	0,015
Wash clothes	Electric	2000	0,02
Wash ware	Thermal	2000	0,066
Dry clothes	Thermal	5000	0,165
Vacuum cleaner	Electric	500	0,005
Computer and printer	Electric	400	0,004
Sound system	Electric	100	0,001
Videogame	Electric	50	0,0005
TV	Electric	100	0,001

As soon as the game begins, the syndic is asked to decide upon certain requests, which are selected in a random manner. For example, one scenario could be that the old man is watching TV solely for entertainment purposes and the student wants to use the computer to complete an assignment. In this case, if necessary, the syndic should allow the student to use the computer and cancel the old man's authorization to watch TV. If the old man is watching a TV report and expecting crucial information, the syndic should balance the importance of the two activities and decide which one is the most important.

If the syndic has success in his role, the game can increase in the difficulty level in the next round of play. The level of difficulty can be controlled through changing some game factors, such as:

a. Decreasing the amount of time allowed for the player to make a decision and to carry through with an appropriate action,
b. Increasing the number of characters engaging in simultaneous activities,
c. Increasing the number of external factors occurring simultaneously,
d. Reducing the gas containers' capacity and
e. Reduction of the electrical generator's maximum power.

If the player wins in any one condition, the game can offer a new phase or level. Another 2D phase could incorporate criteria of water efficiency use, for example. Yet another phase could incorporate the punctuality of the residents' awareness of the problems. In this instance, residents with high levels of efficiency energy awareness could increase their priority to use the energy resources. This is also a prime opportunity to transform the singe-user game in a multi-user one. A 3D phase could also offer illumination criteria.

Competition can be introduced by ranking each player's score. The score can be calculated based upon the final satisfaction level, the amount of time that the generator did not operate at peak capacity, as well as in the differing levels of gas remaining in the containers at the time of replacement.

DEVELOPMENT STATUS

The interface is currently been defined and is still in the development phase. As soon as the interface definition is complete, the game implementation and pilot testing will begin. It is expected that the game implementation process will be completed by June 2006.

ACKNOWLEDGMENTS

This project is financially supported by the Fundação Araucária, Paraná Government Public Agency, Brazil.

The authors would like to acknowledge the valuable contributions from the following individuals: Gustavo Kira, Paulo Victor Caxeiro, Márcia Lissa Azuma, Ole Heydekamp.

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