Activity Promotion System for Saving Energy Aimed at Improving Society and the Environment

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Abstract

This paper introduces the development of the "Activity Promotion System for Saving Energy" aimed at improving society and the environment, as well as demonstrative experiments undertaken at Kansai Science City in Japan and Skellefteå in Sweden, as case studies in Social Value Design activities. By incorporating the psychological factors found through psychological studies into the Activity Visualization Methods, the presence of an Activity Promotion Effect was confirmed in the experiments undertaken at both cities. Moreover, we also confirmed that there are common psychological factors considered important in both Japan and Sweden, and that among those there were differences in the degree of importance attributed to certain factors due to differences in culture and institutions.

Keywords

activity promotion, data visualization method, psychological activity factor, personal adaptation, user interaction

1. Introduction

Social Value Design depicts an abundant future for people and society and creates new value for our customers' business. The individual's desire for ease and comfort is often in conflict with the organization's pursuit of efficiency. The comfort of the individual is at odds with global environmental issues. These are few examples of why it is difficult to grasp and resolve issues from the perspective of both the individual and society. Thus, consideration of the solution methodology based on a balanced perspective that draws on the standpoints of both the individual and society will lead to the creation of innovation.

We at NEC aim at innovation inspired by the two design perspectives: User Experience, which raises value from a human perspective, thereby enabling the comfortable utilization of complex systems and services; and Social Experience, which elevates value from a social perspective, enabling the smooth operation of a sustainable society.

Of the variety of social issues, we have focused on the fields of energy and the environment. The impact of people's energy usage on the environment is large when viewed from a social perspective, but small from a human perspective, often making it difficult for people to realize and therefore unlikely to lead to actions to improve the situation. That is why were devised the "Activity Promotion System for saving energy" which promotes improvement behavior through visual depiction considering the individual characteristics of people. This paper introduces the effect and mechanism of this system along with activities and experiments implemented in Kansai Science City, Japan, and in Skelleftea, Sweden.

2. Psychological Factors Associated with Power-Saving Efforts

Since the attitudes and awareness regarding power saving differs from individual to individual, the effective measures are also different. So first we conducted a questionnaire in collaboration with Professor Shiro Murakami of Nara University, Department of Sociology, who specializes in social psychology, in order to extract the psychological factors involved in power-saving behavior.[1)]

The survey sample consisted of 2,865 men and women (1,429 males, 1,436 females) over the age of 20 (average age 42.6) residing in the six Kinki region prefectures of Osaka, Kyoto, Hyogo, Nara, Shiga and Wakayama. In order to avoid bias among the prefectures and generations, the survey plan

applied stratification of the samples so that the age groups of 20 to 34, 35 to 49, and over 50 for each prefecture would be represented by at least 150 persons each. The questionnaire regarding power-saving activities consisted of 21 items measured on a 7-point scale, such as "saving electricity consumption helps with the household budget" and "saving electricity consumption is embarrassing."

Applying principal factor analysis with varimax rotation to the responses enabled us to confirm the following five-factor structure.

(1) Awareness of personal and social merits
(2) Praise expectation
(3) Ashamed
(4) Bother
(5) Powerless

As (1) included economic merits (saving money) and social merits (good for the environment), it was subdivided into two, and as shown in **Table 1**, a total of six factors that have a psychological impact on power-saving activities was decided. The three factors having a positive impact were Economic merit, Social merit, and Praise expectation, whereas the three factors having a negative impact were Ashamed, Bother and Powerless.

Table 1 Extracted six psychological factors.

IMPACT	FACTOR	MEANING
PROS	(1-1) Economic merit	Expecting economic merits
	(1-2) Social merit	Expecting social merits
	(2) Praise expectation	Expecting praise for power-saving activities
CONS	(3) Ashamed	Concerned that power-saving activities can cause trouble for neighbors
	(4) Bother	Feeling that power-saving is difficult and tiring
	(5) Powerless	Feeling that power-saving by oneself won't make a difference

3. Activity Promotion System Incorporating Psychological Factors

We have been conducting local experiments regarding how the visualization of activities affects the promotion of environmental activities for some time, and have confirmed that visual depiction helps in promoting higher awareness toward environmental activities.[2)]

In addition to this, we added the psychological factors set in Section 2 to design an Activity Promotion System as shown in **Fig. 1**, and incorporated the aspect of visualization as shown in **Fig. 2**. The system automatically obtains power consumption data for each user from sensors, which is accumulated into the activity database to be processed by the information processing unit. The results based on information for one or more users are displayed for user viewing via the visualization method of Fig. 2. Display is in the form of a website, and presumably will be viewed on home PCs, smartphones and tablets.

(1-1) For the economic merit factor, the money amount saved will be calculated by subtracting the current usage from some standard value such as the same month in the previous year, and displayed on screen. Furthermore, as a reference for further action, there is also a function to estimate the billing amount if the appliance continues to be used for a certain length of time.

(1-2) For the social merit factor, a numerical value expressing the percentage of CO_2 reduction will be displayed.

(2) For the praise expectation factor, it displays the day-to-day CO_2 reduction rate of all users, and by applauding the behavior of each other, enables users to experience feedback from others.

(3) For the ashamed factor, in order to discourage shy or hesitating feelings, it displays the state of the others who are also acting positively by use of a marathon metaphor.

(4) For the bother factor, by using the information stored in

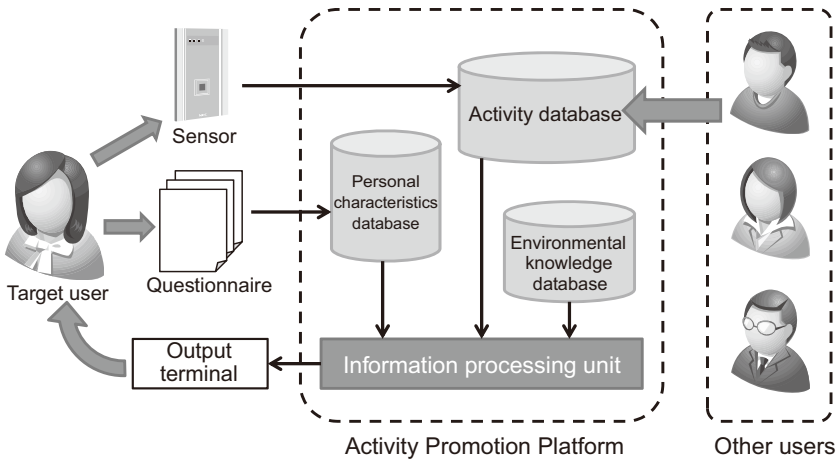

Fig. 1 Activity Promotion System.

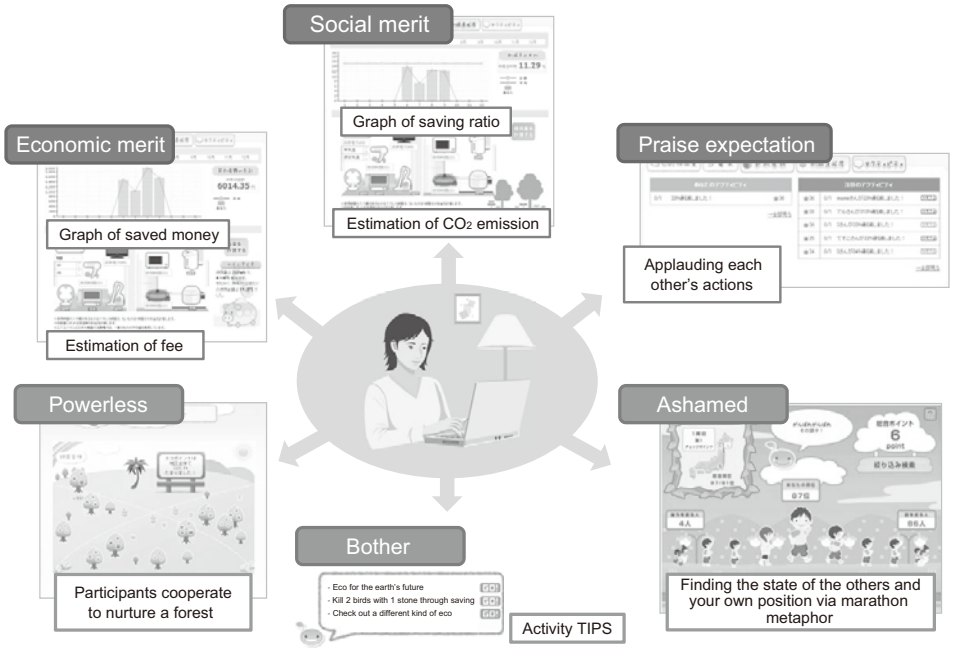

Fig. 2 Visualization for Activity Promotion.

the environmental knowledge database in Fig. 1, it displays a number of activity tips such as examples of what can be done easily to improve performance.

(5) For the powerless factor, it displays the total power savings accomplished by all the system's users together in the form of a tree icon, conveying how the combined efforts of many can have a major impact.

If it is possible to find which of the six factors are considered particularly important by each user, displaying them with more emphasis than the others may lead to more power-saving activity. That is why the system is equipped with a function to run a questionnaire to gauge the characteristics of the user and automatically customize the display accordingly.

4. Experiments in Two Local Communities

4.1 Kansai Science City

4.1.1 Experiment Locale and Settings

Using the system proposed in Section 3, we conducted a demonstration experiment at Kansai Science City. Kansai Science City was selected as a "next-generation energy and social system demonstration area" by the Japanese Ministry of Economy, Trade and Industry in April 2010, and the demonstration experiment there was led by the Keihanna Eco-City Next-generation Energy and Social System Demonstration Project Promotion Council.[3)]

As part of this effort, the "Doshisha Yamate Energy Visualization Demonstration Project" was conducted jointly by the promotion council and the Doshisha Yamate Sustainable Urban City Council. The experiment was carried out during a period of approximately two years from February 2011 to December 2012, targeting 51 households of the Doshisha Yamate district (subsequently expanded to 73 households), to measure energy usage and research whether visualization of such measurements would have an effect on energy consumption.

For measurement, we acquired the gas and electricity usage every five minutes for each household by sensor. As for the visualization capabilities for 6 psychological factors described in Section 3, we introduced parts of them to remove three negative factors of feeling ashamed, bother and powerless onto the visualization screen, and provided via website for participants to view on their PCs (See Fig. 2).

4.1.2 Experiment Results

In this experiment, we possessed the standard CO_2 emission values for the Doshisha Yamate area per number of family members, and by calculating the difference between this reference value and the actual usage value, it was possible to evaluate whether or not there was a reduction in CO_2 emissions. By looking at the CO_2 emissions per month for each household, we found that in 18 months out of 23 there was a reduction compared to the standard value, and that the average amount of reduced CO_2 emissions per month per household was 28.12 kg. The average of standard amount of CO_2 emissions per month per household is 261.19 kg, so that the achieved re-

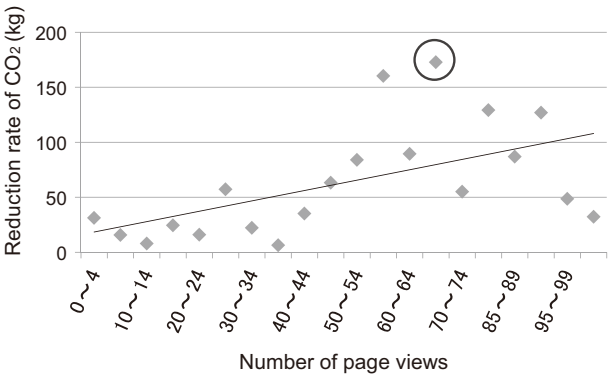

Fig. 3 Relationship between page views and CO_2 reduction rate (Japan).

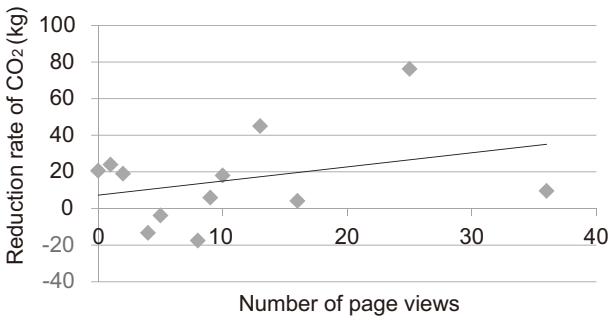

Fig. 4 Relationship between page views and CO_2 reduction rate (Sweden)

duced CO_2 emissions calculates to a 10% reduction.[*1]

Next, we examined the relationship between viewing of the visualization website and the amount of CO_2, mapping out the results in **Fig. 3**. In Fig. 3, we calculated the number of page views per month per household as well as the monthly CO_2 reduction amount, and have listed the average page number value for the same viewed page to facilitate readability. For instance, the point denoting a page viewership of 65 to 69 and CO_2 reduction of 172.75kg means that, in one month a household that logged 65 to 69 page views achieved an average CO_2 reduction of 172.75kg. As seen in Fig. 3, a household with higher page views was more likely to achieve a greater reduction in CO_2 reduction.

From these results, it was possible to confirm that visual depiction introducing psychological factors was effective in promoting actions.

4.2 Skelleftea, Sweden

4.2.1 Experiment Locale and Settings

In Sweden, the Sense Smart City project[4] envisioning a new ICT platform that integrates information related to urban life such as energy, traffic, weather, and the activities and opinions of people, is being implemented. As a trial, a visualization and energy conservation promotion experiment was carried out involving ordinary households in the city of Skelleftea, and the visualization system introduced in Section 3 was incorporated.

During November 2012 through June 2013, we undertook a joint experiment with Luleå University of Technology in Sweden, NEC Laboratories Europe, and NEC Scandinavia. We recruited 10 households as participants, and the electrical appliances of each home were fitted with power sensors to collect data through a Home Service Enabler (device that acts as the gateway to various services in the home) supplied by NEC Laboratories Europe, and visualization as a website viewable on tablet screens placed in each home. Sensors were fitted onto five electrical appliances per home, such as the TV or dishwasher. On the visualization screen, all of the factors shown in Fig. 2 were represented. What's more, a simple questionnaire was posted on the web to gauge which among the factors having a positive impact on behavior (i.e. Economic merit, Social merit and Praise expectation) was most highly regarded and to display it at the top of the page.

4.2.2 Experiment Results

In this trial, we analyzed the impact of visualization in accordance with the usage amount of each appliance. Analysis was performed by using the data value of November 2012, when the experiment started, as the standard value. As a result, we were able to achieve a reduction of an average 17% per month per household. Also, as shown in **Fig. 4**, the relationship between viewing of the visualization screen and the rate of reduction as mentioned in Section 4.1, was confirmed.

In addition to analyzing the usage amounts, we also held a workshop with volunteer participants after the end of the trial, to collect opinions of the participants. As a result, we found that for screens such as the marathon graphic on the visualization website that depicted competition, participants tended to feel more a sense of not performing worse that fell short of fellow participants, instead of wanting to win. We also gained additional insight through opinions saying that in Sweden, where environmental conservation measures and the use of green energy is further evolved than in Japan, negative-impact factors such as Ashamed over saving energy is less likely to be felt, showing us that differences in culture and societal institutions are apparent in the results.

In addition, due to the fact that district heating systems based

[*1] Conversion to CO_2 emissions from the usage of electricity and gas was done using the coefficients in the Kyoto Protocol global warming guidelines.

on hot water are commonly used to heat entire homes in Sweden, and this accounts for a large part of energy cost, among the opinions that were offered to us were those wanting to see all the data for a household including such heating energies, or wanting to see a more accessible interface. We learned the importance of providing information and promoting actions in ways that are more directly integrated with everyday life.

5. Conclusion

This paper introduced the mechanisms for promoting activities pertaining to the saving power and the environment as an aspect of Social Value Design, as well as the results of the experiments implemented in Skelleftea, Sweden, and Kansai Science City, Japan, based on such mechanisms.

By investigating the psychological factors involved in power-saving behavior, and by designing and implementing experiments based on those factors to observe the relationship between power-saving activity and the visualization of those activities, it was learned that in both experiments visualization contributed to the promotion of energy saving. Comparison of the results as well as comments by participants revealed that there are common psychological factors considered important in both Japan and Sweden, but among those there were differences in the degree of importance attributed to certain factors due to differences in culture and institutions.

Although we implemented our field trials over a relatively short period of one to two years, in order to realize a sustainable society it will be necessary for such activities to be carried out over a long period of time. During such, it will be essential that the design fuses the elements of both the Social Experience (involvement of local communities and society from a long-term perspective) and the User Experience (promoting further adaptation to individuals and a closer relationship to people's everyday lives, so that people are able to carry out their energy-saving activities every day). We intend to continue our research with the objective of creating new innovations that draw upon both of these perspectives.

6. Acknowledgements

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