A DIGITAL GAME-BASED LEARNING SYSTEM FOR ENERGY EDUCATION: AN ENERGY CONSERVATION PET

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ABSTRACT
Energy education has been conducted to equip learners with relevant energy conservation knowledge for many years. However, learners seldom put the knowledge into practice and even have few ideas about how to reduce energy consumption. To this end, there is a need to address this issue to improve the efficiency of energy education. One of the strategies is digital game-based learning, which can enhance learning motivation and interaction with learners. In this vein, this study develops an Energy COnservation PET (ECOPET) system using a game-based learning strategy. With the use of a pet avatar, learners were encouraged to use home-energy conservatively in a playful and engaging way. The aim is not simply to teach learners how to reduce energy use, but to engage them in adopting appropriate energy conservation measures. An empirical study was conducted to examine if the ECOPET system could promote learners' understanding of energy conservation. The results demonstrated that the system significantly promoted learners' self-awareness, learning motivation, as well as willingness to conserve energy.
Keywords: energy education; energy conservation; digital game-based learning; self-awareness; learning motivation; pet-nurturing

1. INTRODUCTION

Recently, energy conservation has become a central and rather urgent issue (Shafiee & Topal, 2009) and limiting energy consumption has been taken as a critical solution (Rasanen, Ruuskanen, & Kolehmainen, 2008). In this light, energy education is needed, as it can act well in educating consumers the knowledge of energy conservation (Dias, Mattos, & Balestieri, 2004). As indicated by Yilmaz, Boone and Andersen (2004), students could gradually exhibit a positive attitude toward energy conservation through energy education. However, the effects of energy education in the reduction of energy consumption are still limited (Abrahamse, Steg, Vlek, & Rothengatter, 2005). This may be due to the fact that people have difficulties in putting knowledge into practice. Dahle and Neumayer (2001) indicate that consumers can effectively use such knowledge only when they are aware of energy conservation. In addition to energy awareness, motivation and willingness are also influential factors. McCalley and Midden (2002) state that motivation and willingness activate and maintain certain behavior of energy conservation. Therefore, it is necessary to develop effective strategies to promote self-awareness of energy conservation. Moreover, there is also a need to use strategies, which can increase learning motivation and willingness as well.

One of the strategies is digital game-based learning, which not only promotes learning motivation and willingness, but also increases self-awareness (Owston, 2009). Due to such benefits, game-based learning can be effective in both formal and informal learning contexts (Becker, 2007; Shaffer, 2006; Yang & Chen, 2010; Yien, Hung, Hwang, & Lin, 2011). Research indicates game-based learning encourages active learning through enabling players' control of an in-game avatar (Gee, 2004). Cyber-pets as avatars in a game-based learning environment are also considered as an effective way to encourage learners to adopt a more motivated approach to their learning because pets have positive effects in the improvement of emotion with human-pet interaction (Chen, Chou, Deng, & Chan, 2007).

The abovementioned studies indicate that it is necessary to develop an effective way to promote energy conservation in energy education. Digital game-based learning along with the integration of a cyber-pet would be a possible solution. To this end, the aims of this study are two-fold. Firstly, a digital game-based learning system was developed as a learning strategy to promote the self-awareness regarding energy conservation and enable learning energy conservation with higher motivation and willingness. The system achieves this aim through the successful nurturing of a cyber-pet in a game-based learning environment. Within this environment, learners need to appropriately operate electric appliances to ensure a balance between the comfort and survival of the pet and the reduction of the energy consumption. Secondly, an empirical study was conducted to examine how this system affected learners' self-awareness, learning motivation, and willingness to conserve energy.

2. LITERATURE REVIEW

2.1 Energy education

Energy education has been conducted for many years. Energy education facilitates consumers to identify the effective way to save energy (DeWaters & Powers, 2011). Nevertheless, a study has shown that, while almost everybody states that they want to conserve energy, this often does not translate into action (Vastamaki, Sinkkonen, & Leinonen, 2005). For this reason, energy consumption has not decreased significantly in reality (Boyde, 2002). This obstacle may be due to the fact that consumers usually neither know how much electricity their household appliances consume nor have any idea of how to save electricity in an appropriate manner. Therefore, providing feedback at the right moment helps consumers learn how to adopt appropriate levels of electricity consumption (Haakana, Sillanpaa, & Talsi, 1997). More specifically, feedback regarding energy use can encourage conservation behavior (Brandon & Lewis, 1999), and feedback with adaptive energy saving tips can increase the average energy saving rate (Tao, Wei, Guoping, Jiang, & Xiyu, 2007).In addition, it is important that the goal of energy saving should be reachable. Goals that are too simple or too complex often result in external attribution of failure. van Houwelingen and van Raaij (1989) found that assigning energy conservation goals with a level of difficulty to electric appliances would lead to greater energy savings than using feedback alone.

Energy education is a process that helps learners put energy conservation into practice. Before learners can implement the practical methods of energy conservation, they must develop a social consciousness toward energy consumption (Roberts & Bacon, 1997). For fostering the development of social consciousness of energy conservation, it is necessary to increase learner's self-awareness to measure the effectiveness of energy conservation (Allen, 1982). Thus, there is a need to develop useful instruments to help learners make simulated energy-saving decisions with the design of feedback and task complexity mechanisms for promoting the understanding of energy conservation. A digital game-based learning system is one of the potentially effective instruments.

2.2 Digital game-based learning

Due to the fact that digital games have potential impacts on education, much attention has been paid to the relationship between digital games and education (Chiang, Lin, Cheng, & Liu, 2011; Yang, Chen, & Jeng, 2010). For example, a study by Kirriemuir and McFarlane (2004) identifies two key themes that are common to the development of educational games, including the desire to harness the motivational power of games to make learning fun and a belief that the process of learning by playing games is a powerful learning tool. Digital games have various factors which are valuable for education (de Felix & Johnston, 1994; Prensky, 2001). These factors can be divided into several categories: fun/fantasy, rules, goals, outcomes and feedback, conflict/competition/challenge/opposition, interaction, and representation and story.

Aside from the aforementioned factors, the majority of educational games tend to be exploratory that enable learners to be motivated and gratified with learning activities in the games (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005; Chen, Yang, Shen, & Jeng, 2007). Besides, curiosity seems to be the primary component of motivational power which attracts learners' attention to actively seek out varied sources of challenge in game play (Moon & Baek, 2009). Past research also demonstrate that educational games enable learners to enjoy learning through game play (Chang, Yang, Yu, & Chan, 2003; Hong et al., 2009).

With regard to the design of educational games, Garris, Ahlers and Driskell (2002) propose the Input-Process-Outcome game model, which focuses on instructional programs that demonstrate certain characteristics of digital games. These characteristics trigger a cycle that includes processes of user judgments or reactions (such as enjoyment or interest), user behavior (such as greater persistence or time spent on task), and further system feedback.

2.3 Environmental and conservation awareness games

Past research indicates that digital games can be utilized for energy education with various topics in environmental and conservation awareness. Several studies apply board games as tools for increasing environmental and conservation awareness. A study by Hewitt (1997) demonstrates that children can be taught environmental topics through the use of board games and significantly improve their knowledge and understanding of various environmental concepts and behavior. Another study by Evans et al. (2007) uses board games as various environmental dilemmas to examine participants' environmental awareness. Results show that participants not only have positive attitudes regarding the environment but also behave in an environmentally responsible manner.

Simulation games are the other type of games that are used for supporting environmental and conservation awareness. A study by Torres and Macedo (2000) demonstrates that simulation games can be used to promote environmental awareness and explore attitudes toward environmental conservation. Moreover, Hansmann, Scholz, Francke and Weymann (2005) show that the simulation game can effectively improve the environmental knowledge, attitudes, and behavior of the players.

To achieve the goal of energy conservation awareness, learning motivation, willingness to conserve energy, as well as behavioral change, several useful features in the aforementioned environmental and conservation awareness games are needed to be considered during the design process of a digital game-based learning system. Those features include interaction and feedback with explanation tips, simple or complex levels of game tasks, and possible outcomes for a real world environment.

3. SYSTEM DESIGN AND IMPLEMENTATION

3.1 Design rationale

The design rationale for the proposed Energy COnservation PET (ECOPET) system is depicted in Figure 1. It illustrates that learners transform their knowledge of energy conservation into a consciousness of energy conservation by measuring self-awareness through conducting game-based learning.

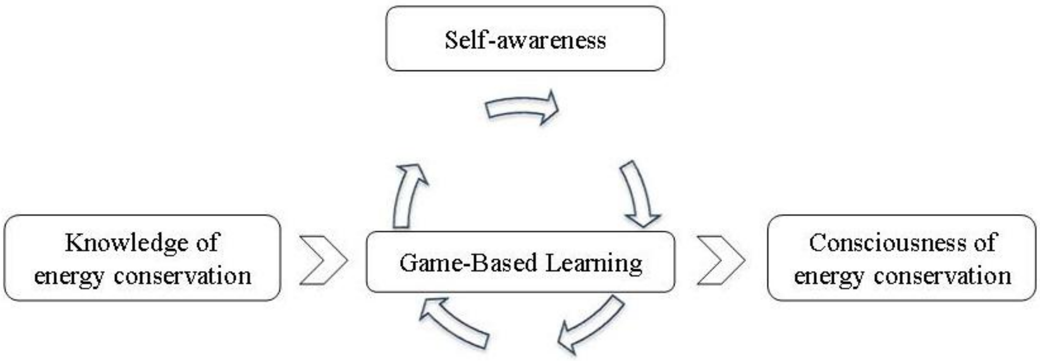

Figure 1: Design rationale of the ECOPET system.

Based on the design rationale, learners are responsible for nurturing a cyber-pet dog that is present in various virtual scenes, each of which contains various electric appliances. The pet can then "suggest" those electric appliances that are required at each moment according to the virtual environment and the inner variation of the "desire" of the pet. Within this scenario, learners need to respond to the demands of the pet by controlling interfaces of electric appliances. During the game, learners are given specific quotas of electricity for each game. They need to make decisions based on the dual goals of taking care of the pet properly and saving as much electricity as possible.

Since different levels of knowledge on energy conservation may influence electricity usage, feedback and task complexity mechanisms were designed. The feedback mechanism provides information such as the amount of electricity consumption and energy saving tips for each electric appliance. Such feedback can help learners use electric appliances properly. On the other hand, the task complexity mechanism provides various tasks with different levels of complexity. The complexity of tasks varies according to the amount of feedback and control panels and the level of knowledge to use electric appliances appropriately. Learners need more knowledge to operate electric appliances precisely for more complex tasks.

Based on the aforementioned design, there are two phases in the system. Learners may enter the second phase if they satisfy to keep the pet alive for more than a specific duration without breaching any restrictions or consuming excessive electricity. At the second phase, the game becomes increasingly difficult as the available electricity is reduced. Learners may lose the game if they exceed the duration set in the game or fail to provide significant care to the pet.

3.2 Learning model

Figure 2 shows the learning model of the ECOPET system, which is designed based on the game model by Garris et al. (2002). The learning model comprises three steps: input, process and outcome. The input includes energy saving tips while using electric appliances and information about the estimated consumption of electric appliances in common use. These characteristics trigger a cycle of elements, which include user judgments (switching on electric appliances), user behavior (adjusting the control panels of electric appliances), and system feedback (tips of saving energy after switching on electric appliances). During the process, learners are always aware of their energy consumption which guides them to transform knowledge into a consciousness of energy conservation. Consequently, the learning outcome of taking the system would promote learners' self-awareness, learning motivation, and willingness of energy conservation.

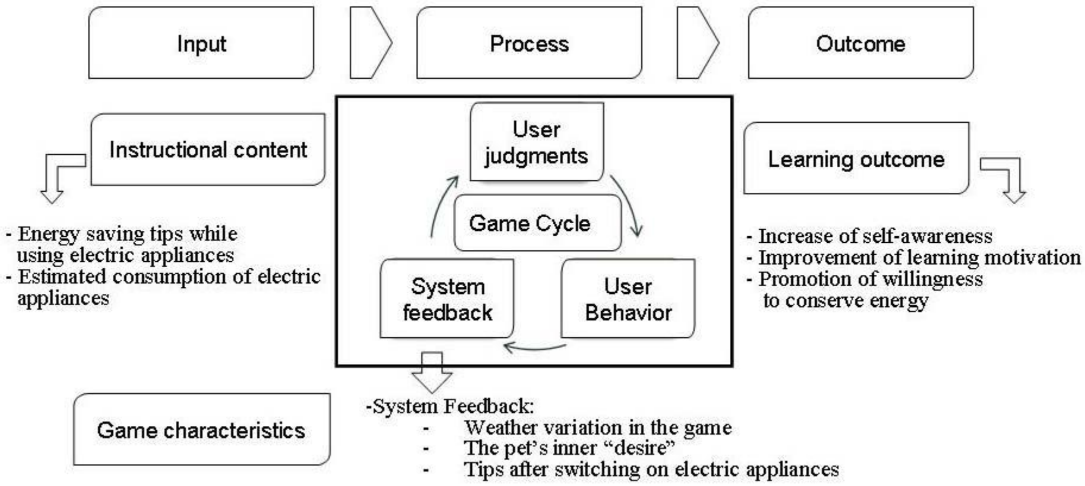

Figure 2: Learning model of the ECOPET system.

3.3 User interface

Figure 3 illustrates the user interface of the system, which is made up of two categories: information and function. In the information category, learners are given information about the states of the game, including current scene, game level, level of electricity consumption, virtual time, temperature, humidity, and brightness. In the function category, learners can control functions provided by the system, including the system function, switching scene, changing the settings of electric appliances, and interacting with the pet.

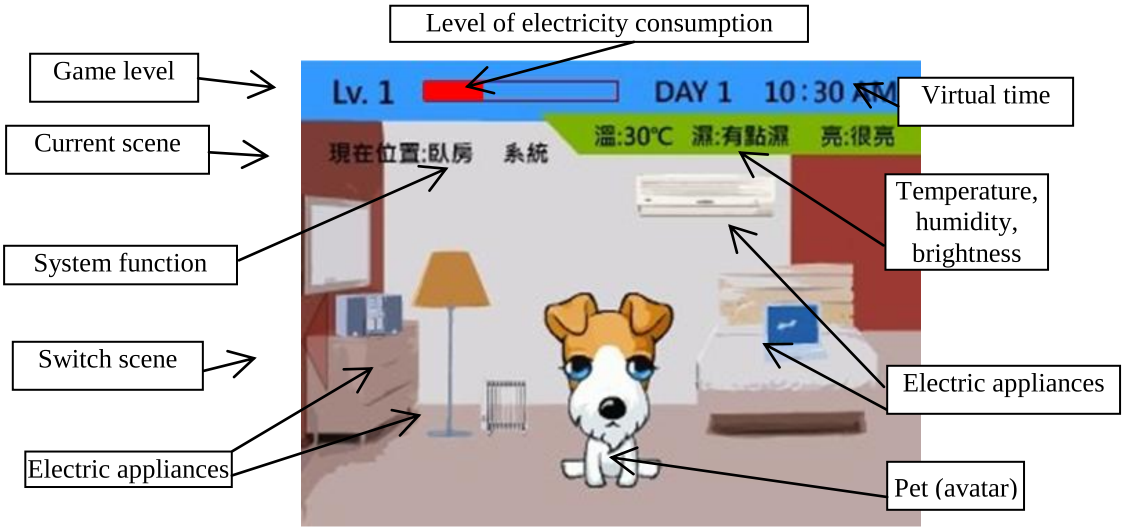

Figure 3: User interface of the ECOPET system.

There are four scenes in the game, and each represents a living space. Learners can switch between the four scenes throughout the game, as illustrated in Figure 4. Different scenes may contain various electric appliances. For instance, a balcony scene is furnished with a washing machine, a tumble dryer and an electric hot-water heater. The information about how much electricity is consumed and the current status is displayed on the screen for learner reference.

Figure 4: Four scenes from the game.

The ECOPET system provides a feedback mechanism to help learners consume less electricity, offering information such as the current status of electricity consumption and energy saving tips about the electric appliances. The system simulates and monitors the most comfortable environmental variables of the scenes where the pet lives. Once the environmental variables in the living space are beyond the most comfortable range, the system triggers feedback, e.g. "It's too hot." The learner should respond to the feedback appropriately, such as adjusting the target temperature to meet the feedback requirements. Through the interactions under the feedback mechanism, learners' awareness of energy conservation will be increased.

Different electric appliances are equipped with different control panels depending on their distinct attributes, e.g. a floor lamp has only a power switch panel but an air conditioner has various control panels including a power switch, timer set, and temperature set. According to the design of complexity mechanism, the system provides tasks with different levels of complexity. For the simple tasks, learners only need to know how much electricity is consumed, e.g. how many kilowatts per hour a floor lamp consumes for using it appropriately. More complex tasks require learners to be aware of more detailed information. For example, learners need to know how many kilowatts are consumed per hour, how much electricity can be saved for increasing one degree centigrade, what the indoor thermal and humid comfort range is, and how much time is required to create a comfortable environment when using an air conditioner. Figure 5 illustrates examples of simple and complex tasks with corresponding feedback while the learner is interacting with the system. As shown, only the information of electricity consumption is displayed for the simple task; various control panels accompanied with feedback are displayed for the complex task.

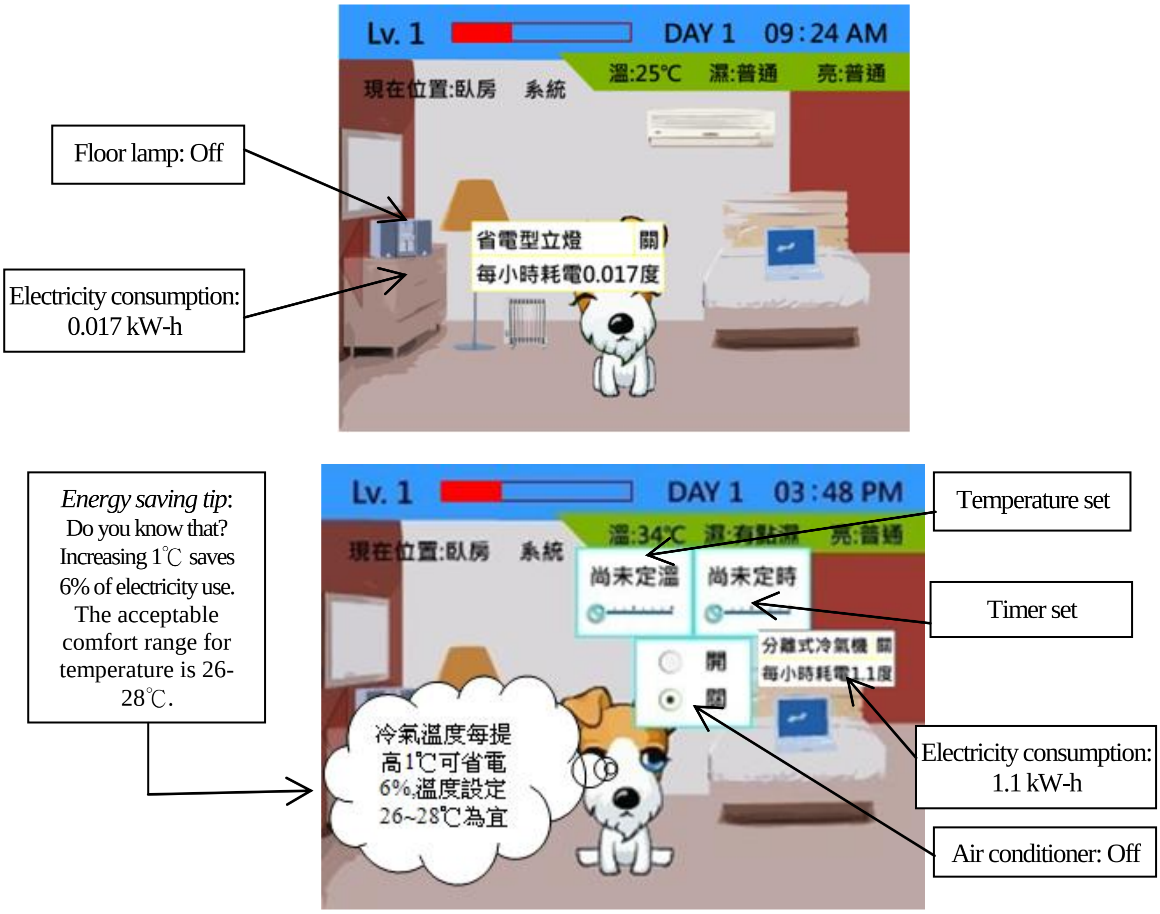

Figure 5: Examples of simple (upper) and complex (lower) tasks with corresponding feedback.

4. METHODS

The participants were students enrolled in a graduate institute in Taiwan. They were randomly chosen from a pool of volunteers. Fifteen of the participants were male and eight were female. Their ages ranged from 23 to 31 years old.

The instruments implemented in this study included three questionnaires and a videotape of the participants operating the system. The questionnaires were used to assess participants' self-awareness of energy conservation, learning motivations toward ARCS (Keller, 1983), and willingness to conserve energy. The questionnaire for accessing participants' self-awareness of energy conservation adapted from Allen (1982) contained 12 questions and was used for both pre-test and post-test to compare the difference in participants' perceptions about energy problems. The other two questionnaires were only conducted in the end of the study to examine participants' learning motivation and willingness to conserve energy. These two questionnaires contained 16 questions and five questions, respectively. All of the three questionnaires used a five-point Likert scale consisting of the response options: strongly agree, agree, neutral, disagree, and strongly disagree.

This study adopted Cronbach's alpha coefficient to measure the internal consistency reliability of the aforesaid three questionnaires. Table 1 shows that the values of Cronbach's alpha for the pre-test and post-test of participants' self-awareness of energy conservation were 0.77 and 0.62, respectively. Besides, the values of Cronbach's alpha for the learning motivation and willingness to conserve energy were 0.74 and 0.78, respectively. These results indicate that the internal consistencies of the three questionnaires were acceptable.

Table 1: Reliability of the three questionnaires.

Questionnaires	Cronbach's alpha
Self-awareness of energy conservation	0.77 (pre-test), 0.62 (post-test)
Learning motivation	0.74
Willingness to conserve energy	0.78

The experimental procedure was conducted as follows. Participants were given an instruction at the beginning, and they were then asked to fill in the pre-test questionnaire on the self-awareness of energy conservation.

Subsequently, participants started to operate the system. Meanwhile, video recording began at the same time. The recorded video was used to further analyze learners' behavior while operating the system. The system ran for 90 minutes and stopped, regardless whether participants finished the tasks or not. Finally, participants completed the three questionnaires right after they finished the session.

The data collected from the three questionnaires were coded for quantitative analyses. The participants' responses given on the Likert scale were coded as follows: 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, and 1 = strongly disagree. Descriptive statistics for the three questionnaires were analyzed in terms of mean and standard deviation. Additionally, a paired samples t-test was also applied to conduct data analyses on the questionnaire of the participants' self-awareness of energy conservation. Furthermore, an analysis of the video recordings was conducted to observe learner behavior.

5. RESULTS AND DISCUSSIONS

5.1 Self-awareness of energy conservation

A comparison was made between the results of the pre-test and those of post-test to analyze the changes of participants' self-awareness of energy conservation before and after taking the ECOPET system. Table 2 shows the results, indicating that there is a significant difference between the pre-test and post-test in participants' self-awareness of energy conservation ($p=0.013<0.1$). More specifically, the mean of the post-test is higher than those of the pre-test. This reveals that participants' self-awareness of energy conservation is significantly improved after using the system. This result echoes the findings of previous studies (Torres & Macedo, 2000), which show that digital games can enhance learners' environmental awareness. A possible explanation may be because the process of operating the system includes various kinds of manipulations on energy conservation. In particular, the design of feedback and task complexity mechanisms played important roles to increase participants' self-awareness of energy conservation.

Table 2: Results of participants' self-awareness of energy conservation.

	Mean	SD	T	p
Pretest-posttest	-.33	.53	-2.726	0.013

5.2 Learning motivation toward ARCS

According to the ARCS motivational model, the items of the questionnaire on learning motivation were divided into four categories. Table 3 shows the results of participants' learning motivation toward ARCS, which indicate that participants highly rated all of the four categories. More specifically, the average mean of the four categories is 3.99, which indicates that the ECOPET system promoted participants' learning motivation. The details of the four categories are described below.

Table 3: Results of participants' learning motivation toward ARCS.

Categories	Mean	SD
Attention	3.90	.89
Relevance	4.20	.78
Confidence	3.73	.90
Satisfaction	4.12	.75
Average	3.99	.83

The mean of the *attention* category is 3.90, which reveals that participants maintained sufficient attention during the game-play. The mean of *relevance* category is 4.20, which indicates that participants considered the contents of the system relevant to them. This means that participants comprehended what this study was conducted for. The mean of *confidence* category is 3.73, which indicates that participants were quite clear about the significance of every action and the manner in which the game proceeded. For example, in response to the question "I would try my best to find the most economic ways to save electricity", 100% of the participants agreed. This indicates that participants not only satisfied the needs of the pet, but also tried to seek the most economic ways to save electricity. In other words, participants were confident of the learning contents provided in the system. Only 50% (with mean 3.35) of the participants agreed with the question "I can personally identify with the pet.", which is lower compared to other ones. This may be because the pet would not operate electric appliances in the real world though it might invoke pity from the participants. Finally, the mean of the *satisfaction* category is 4.12. This result reveals that participants were satisfied with the contents provided in the system, which was helpful to their emotions and their understanding of energy conservation. For example, in the question "I know more about the electricity consumption of electric appliances", 90% of the participants agreed. This shows that participants' knowledge about the electricity consumption of electric appliances could be improved after using the system.

The aforementioned results are consistent with those of past studies (Ryan, Rigby, & Przybylski, 2006; Yee, 2006), which demonstrate that digital games can effectively improve learning motivation. This may be because the ECOPET system provides an interesting environment where participants can manipulate various electric appliances to save electricity through nurturing a cyber-pet. Although the mean for the confidence category is lower than other categories, it is still higher than the average of the five-point Likert scale. Future research need to address the issue of introducing cyber-pets into a human environment.

5.3 Willingness to conserve energy

Table 4 shows the results of the questionnaire in terms of participants' willingness to conserve energy. The results show that participants answered the majority of the questions in an affirmative way. More specifically, over 80% of the participants agreed with the questions about their willingness to conserve energy, especially for Questions 2 and 4 which had a high rate of agreement (95%). It indicates that participants could obtain the knowledge of energy conservation and were willing to decrease consumption of energy by changing their current habits regarding the use of electric appliances. Besides, the results also show that most participants agreed with each of the other questions, which all had mean scores of over 3.95 as well. These results are in line with those of Al Mahmud, Dadlani, Mubin, Shahid and Midden (2007), which demonstrate that digital games can motivate people to change their willingness to conserve energy. This reveals that most of the participants were willing to put energy conservation in practice after taking the ECOPET system. These results indicate that participants not only became likely to change their behavior toward saving energy, but also acquired a sound understanding and skills for changing actions. Actually, these are the major objectives that the ECOPET system intends to achieve.

Table 4: Results of participants' willingness to conserve energy.

Questions	Agree	Disagree	Mean	SD
1. The understanding and skills that I have learned from the system have changed my attitude toward energy saving.	85%	5%	3.95	.69
2. The understanding and skills that I have learned from the system will help me change the habit of using electric appliances.	95%	5%	4.10	.64
3. I will start to think whether I habitually use electric appliances correctly.	80%	0%	3.95	.61
4. I would consider to decrease my consumption of energy by changing the habit of using electric appliances.	95%	0%	4.20	.52
5. I would suggest others decrease their consumption of energy by changing the habit of using electric appliances.	80%	5%	3.95	.76
Average			4.03	.64

5.4 Behavior of learners

According to the analyses of the recorded video, participants' learning behavior can be classified into four categories: adjusting the control panels of electric appliances, adjusting the default value of using electric appliances, adjusting the duration parameters to find out the lowest satisfaction level of each electric appliance for the pet, and reviewing the information of electric appliances after receiving tips. Different categories represent participants' different levels of understanding on operating electric appliances in the system. Analyses on the behavior of learners could be useful to explain the results of the study.

The first category involves the investigation of whether participants have tried to adjust the control panels of electric appliances. The result shows that 100% of the participants implemented this adjustment. This could be due to participants' curiosity on the variety of functions and control panels provided by the system. The findings indicate that the participants paid attention to the proper use of the control panels of the electric appliances. It may be because participants' curiosity motivated them to make the aforementioned adjustments. It suggests that catching users' attention is a useful approach for energy saving. This result confirms those of the past study (Kashdan, Rose, & Fincham, 2004), which indicates that curiosity could be the primary force to motivate participants to engage in the game. In other words, appropriate levels of curiosity generate high values of entertainment (Yannakakis & Hallam, 2007).

The second and third categories are two different levels, basic and advanced levels of the acquired knowledge related to the adjustment of electric appliances. The second category involves assessing whether participants have tried to adjust the default values used in the electric appliances. The result shows that 75% of the participants adjusted the default values. This may be due to the aim of the game to satisfy the pet using as little electricity as possible. For example, the pet was satisfied as long as the air conditioner was set to 28 degrees centigrade; however, the default temperature of the air conditioner was set to 24 degrees centigrade. Participants could reduce the electricity consumption and still allow the pet to live comfortably by increasing the temperature from the default value to the appropriate value which they perceived. Moreover, the third category involves the investigation of whether participants tried to adjust the duration parameters to identify the lowest satisfaction level of each electric appliance for the pet. The result shows that 65% of the participants implemented this adjustment, which indicates that they tried to adjust the time parameters of the electric appliances repeatedly by estimating the lowest satisfying level. Indeed, this action could help participants learn what the best duration to use each electric appliance was. In other words, participants were able to identify the most economic way to use the electric appliances. The aforementioned findings reveal that participants made great efforts in the adjustment of electricity of using electric appliances to save energy. Participants' behavior could be delineated using the social learning theory (Bandura, 1977). More specifically, after many trial and error endeavors, the best approach could be found by the participants. It reveals that participants became accustomed to using electric appliances in an electricity-saving manner. These results reflect the goal of the system, which assists participants to seek out the most economic use of electricity. Although the ways to acquire the knowledge of saving electricity are similar for the aforementioned two levels, there is still little difference between them. The participants who acquired the advanced level of knowledge needed to pay much more attention to seek out the most economic level of energy consumption in using the electric appliances.

The fourth category involves the investigation of whether participants reviewed information about electric appliances after they had received energy saving tips. The result shows that 55% of the participants implemented what they have learned into practice. Although the tips for saving electricity were related to each electric appliance, insufficient corresponding adjustments were made for all the electric appliances during operating the system, i.e. more clear and corresponding adjustments information is needed to facilitate participants to use electric appliances in a saving manner. Nonetheless, more than half of participants reconsidered and reviewed how to use electric appliances after reading the tips. This result echoes those of Garris et al. (2002), which propose that learners transform their understanding of energy conservation into conscious actions of energy conservation. These findings indicate that the participants could use their knowledge learned from the system. It is in line with the elaboration likelihood model of persuasion theory (Petty & Cacioppo, 1986), which shows that participants were persuaded by the provided information, e.g. energy saving tips in this study, and considered such information as the guidelines to change their behavior. These findings suggest that incorporating useful features into educational games can promote energy education.

6. CONCLUSION

This study adopted a game-based learning strategy with the aim of developing a learning environment based on the notion of pet-nurturing. Participants need to make efforts in nurturing the pet successfully, as well as conserving energy. In the proposed ECOPET system, participants learned how to keep balance between satisfying the pet's needs and saving electricity. During the process of game-play, participants acquired knowledge about how to use electric appliances, and became more aware of their own energy conservation by repeating the game cycle in the system. The results of the empirical study have demonstrated that the system can positively promote participants' self-awareness of energy conservation, learning motivation, and willingness to embrace energy conservation.

This study has explored possible features for designing a game-based learning system for energy education, including feedback and task complexity mechanisms. Additionally, the system utilizes a virtual environment that is connected to the energy consumption issue in the real-world. The system enables electric appliance interaction to promote sustainable behavior and create awareness around electricity use. Evidence shows that participants adopt positive attitudes to find the best way of adjustment for saving electricity. The abovementioned design features are innovative compared to traditional teacher-centered teaching fashion on energy education. While traditional teaching methods often fail to provide learners with actual energy conservation experiences in learning by doing, the ECOPET system, with designed features, creates a challenging edutainment environment and simulated real-world scenery to promote participants' awareness and behavior of energy conservation. Accordingly, participants develop self-awareness of energy conservation during the game-play by practice and learning. This finding suggests that incorporating useful features into educational games can promote energy education.

The abovementioned findings demonstrate the values of providing support of a digital game for energy education. Although the present study has yielded findings that have pedagogical improvements, the design of the cyber-pet nurturing in the digital game may raise some issues, such as the relevance of introducing the cyber-pet into a human family for directing the use of electric appliances. Therefore, further empirical studies need to clarify this avatar concern and examine the differences between various avatars in the digital game-based learning system. In this study, graduate students were selected as the participants to prove that energy conservation is not only affected by energy knowledge but it also associates with energy awareness, motivation and willingness.

However, different results may be produced if the study is conducted on a younger population. It is also of value to conduct a study, by using the game, on two different age groups to see which group really responds to change behavior of energy conservation. There is also a need to conduct future research in a number of areas, such as enhancing the variety and suitability of the game options, adding more learning contents that are related to energy conservation education, and conducting a long-term experiment that is able to examine learning effectiveness.

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