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A Learning Cycle Approach to Developing Educational Computer Game for Improving Students' Learning and Awareness in Electric Energy Consumption and Conservation

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ABSTRACT

Educating on the knowledge of electric energy consumption and conservation has been becoming a focus and rather urgent issue in energy education. Although several researchers have attempted to apply teaching and learning strategies to promote students' conceptual understanding on the topic, they still have sub-optimal conceptual understanding of what the major factors of energy consumption are. This led to less awareness of electric energy conservation. With the benefit of educational computer game in motivating students' learning, this study developed a computer game based on a learning cycle approach for assisting learning on the topic. When using the computer game, the students were encouraged to use electrical appliances for certain durations. To examine the effectiveness of the computer game, the study was conducted with 129 tenth grade students in eastern Bhutan. The experimental results showed that the computer game significantly improved the students' learning achievement on energy consumption as well as their awareness on electric energy conservation.

Keywords

Electricity, Energy consumption, Inquiry, Game-based learning, Self-awareness

Introduction

With the significance of saving energy, researchers are deeply aware of the importance of teaching and learning energy concept in classrooms. A great deal of effort has put into research related to the development of energy educational program to facilitate students to identify the effective way to save energy (DeWaters & Powers, 2011). Nevertheless, some researchers showed that such programmes often were not put into actions (Vastamäki, Sinkkonen, & Leinonen, 2005). Moreover, previous research indicated that most people have only a vague idea of how much electricity is consumed by their household appliances or do not have any idea of how to save electricity in an appropriate manner, and what sort of difference they could make by changing day-to-day behavior or investing in efficient measures. For this reason, energy consumption has not decreased significantly in reality (Boyde, 2002). Therefore, teaching them the basic concepts, such as calculating energy consumption by each of their household electrical appliances and what would be the approximate monthly electric bill, how to save unnecessary waste of energy by providing feedback at the right moment, are necessary for developing cautiousness in energy usage. Moreover, the adaptive energy saving tips could help students learn to adopt appropriate levels of electricity consumption (Haakana, Sillanpää, & Talsi, 1997). In this view, the importance of energy consumption and conservation concept in physics or in energy education several researchers have attempted to promote students' conceptual understanding to equip with appropriate ways to educate this concept for a secondary school level. For example, Gustafson and Branch (2002) designed instructional models which fit varied learning situation and introduced the concept of electrical energy consumption by explaining in an effective way. Bates (2003) applied the methods of instructional technology to serve the concept. However, students still lack the knowledge of a daily life electrical appliance and they have few conceptual understanding about the major factors of energy consumption. Therefore, there is little knowledge and awareness on energy conservation.

With the rapid growth of technology-enhanced learning approach, educational computer game has been recognized as to motivate students' learning in several courses. In recent years, there have been many developments of computer games that were used for supporting learning and teaching in different levels of education. For example, Cai, Lu, Zheng, and Li (2006) developed an immersive protein gaming for biology course. Virvou, Katsionis, and Manos (2005) designed a virtual reality games to teach geography students. Connolly, Stansfield, and Hainey (2007)

developed computer game for a software engineering course. Yien, Hung, Hwang, and Lin (2011) proposed a game-based learning approach in improving students' learning achievements in a nutrition course. Yang, Chien, and Liu (2012) developed a digital game-based learning system for energy education for the children in the school. These studies have pointed out that the educational computer game could engage the students in meaningful -motivational learning. But on other hand, without incorporating educational theory or applying teaching and learning strategies, the educational computer games might not be significant for a meaningful learning (Ke, 2008). Consequently, this study attempts to apply the learning cycle approach as an educational-theoretical framework for developing an educational computer game, in which students are able to explore and explain the situation occurring in the developed game for constructing electric energy consumption and conservation knowledge. Meanwhile, the developed game characteristics are utilized to promote their awareness on energy conservation.

To our knowledge, there is no research concerning about the integration of multimedia into the 5E learning cycle-based activities for improving students' learning and awareness in electrical energy consumption and conservation. With the benefit of the 5E learning cycle model and the educational computer game, this study incorporated such learning approach into the educational computer game serving as supplementary material after a traditional lecture of abstract concepts of household electrical energy consumption and conservation. An experiment was conducted in a secondary school Physics course "electric energy consumption and conservation" to investigate the following research questions:

- Do the students who learn with the educational game based on a learning cycle approach have better learning achievement than those who learn with the conventional teaching approach?
- Do the students who learn with the educational game based on a learning cycle approach have better awareness toward energy conservation than those who learn with the conventional teaching approach?
- How is the students' satisfaction toward the educational game based on a learning cycle approach?

Literature review

Educational computer game

Computer games play an important role in any fields of education. The use of computer games in education has shown positive learning outcomes by using it as a tool for instructional purposes. Several studies showed that the use of educational computer games increase motivation and better learning achievement. The positive impact was well received as new approach in teaching by many students when compared with traditional teaching. For example, Sofoluwe (2007) stated that educational games are good tools to promote students participation in learning activities and then to motivate them in their learning as it encourages learning within enjoyable environment. Through game play, teacher can encourage student's abstract thinking into a concrete concept and further foster their higher order thinking abilities. Computer games are able to boost learning motivation of players through its features like adventures, challenges and fantasies. Moreover, playing educational computer game for long-term had a positive effect on students' learning abilities and construct knowledge (Burguillo, 2010; Liu, Peng, Wu, & Lin, 2009). Computer games are claimed to have effects on cognitive development through visual skills including "spatial representation," "iconic skill," and "visual attention." While playing games the player(s) become more skilled in games and their visual attention becomes proportionally better. Moreover, Dondlinger (2007) articulated that motivation by using game can promote the learning achievement even in the complex concept. For example, a study of Ke (2008) indicated that the educational computer games had more impact in promoting motivation in learning than conventional chalk and talk method.

In general, games are employed to motivate students to take responsibility for their own learning that leads to intrinsic motivation. Prensky (2011) indicated that gaming activities had potential to engage the students into a state of flow and consequently cause better learning through focus and pleasant rewards while increasing their motivation and attainment. Consequently, in recent years numerous educational computer games have been designed in several difficult subject domains to supplement teaching and learning for improving students' academic achievement, including mathematics (Lee & Chen, 2009), language (Chen, Liao, Chien, & Chan, 2011), software programming (Connolly et al., 2007), management education (Chen et al., 2013; Kiili, 2007), medical education (Moreno-Ger, Burgos, Martínez-Ortiz, Sierra, & Fernández-Manjón, 2008), and sports education (Mueller, Gibbs, & Vetere, 2010).

Educational computer games have been used to support active, productive, creative and collaborative learning methods (Hoppe, Joiner, Milrad, & Sharples, 2003). However, the integration of the computer game approach into the classroom, teaching does not necessarily ensure successful learning. Therefore, to ensure effective and successful learning, development of any innovative approach need to incorporate appropriate learning strategies that fit both in the learners and to the teachers (Charsky & Ressler, 2011; Chuang & Chen, 2009; Wang & Chen, 2010).

A learning cycle approach

The 5E learning cycle model-oriented learning cycle approach is a realistic, constructivist method of learning which employs students through well-designed learning process (Bybee, 2004). It is based on the constructivism theory of John Dewey and Jean Piaget. It was first designed by Robert Karplus in the early 1960s, and later in 2004, Bybee conducted full study and developed a method, named 5E Learning Cycle model. According to Bybee (2004), the 5E learning cycle model consists of five phase inquiry approaches-: (1) Engagement: In this phase the teacher or a curriculum task accesses the students' prior knowledge and engages them in a new concept through the use of short activities that promote curiosity and stimulate prior knowledge; (2) Exploration: During this phase students are provided opportunity to experience activities within current concepts, skills and processes. In this phase, conceptual change is facilitated with guidance from teacher/instructor; (3) Explanation: This phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to share and explain their understanding of the concepts, skills and processes that they have learned. Here, it also provides opportunities for teachers to clarify students' misconceptions and help them in introducing new concepts, process and skills; (4) Elaboration: As they received theoretical concepts, process and skills, now they need to experience further related to new situation. This phase enable students to extend the concepts they have learned, link to other related concepts and apply their conceptual understandings into the real world situations in a newer ways. Moreover, teacher further challenges and extends students' conceptual understanding and skills of the concept by conducting additional activities that focuses on adding breadth and depth to current understanding; and (5) Evaluation: The evaluation phase provides students' opportunities to self-assessment as well as formal assessment for both students and instructors to determine how much learning and conceptual understanding has taken place and whether they have met the learning outcomes.

Previous studies advocated that the instruction based on the 5E learning cycle model had positive effect on students' achievement. Moreover, the 5E learning cycle instruction was able to relate their conceptual learning with ability to apply in their daily life situations, which was the gap in that of traditional learning method (Kaveevivitchai et al., 2009; Kaynar Tekkaya, & Cakiroğlu, 2009; Liu et al., 2009). For example, Kaynar et al. (2009) showed that the 5E learning cycle model was more effective in enhancing students' achievement in cell concepts topic over the traditional learning. Beside the 5E Learning Cycle model has been recognized as one of the best teaching and learning approach in learning abstract concepts in several subjects in school education (Cepni & Sahin, 2012; Tuna & Kacar, 2013). For example, Cepni and Sahin (2012) concluded that students who learned with the instruction based on the 5E learning cycle model had better learning outcomes than those who learned with other teaching methods in learning buoyancy force. A recent study by Tuna and Kacar (2013) indicated teaching trigonometry concepts with 5E learning cycle model enhanced students' academic achievement and longevity of their knowledge. Therefore, the aforementioned researches suggest the 5E learning cycle model is one of the widely-adopted pedagogies that involve brain-hands-mind in learning for enhancing students' conceptual understanding. This model is a guided inquiry-based scientific pedagogy (Bybee, 2004) where students are engaged in new concept by relating their previous knowledge by exploring and explaining through their experiences, then elaborating on what they have learned, and eventually evaluating their understanding on that new concept under the guidance of teachers (Uzunöz, 2011). When organized and correctly operated, this 5E learning cycle model enhances not only the students' achievement but also the permanence of knowledge in various fields of education.

Development of an educational computer game based on the 5E learning cycle model for energy consumption and conservation

With the benefit of the 5E learning cycle model and the educational computer game, this study incorporated such learning model into the educational computer game serving as supplementary material after a traditional lecture of abstract concepts of household electrical energy consumption and conservation. The developed educational computer game has scoped to make students understand the basic concept of daily household energy usage by identifying the basic factors that determine energy consumption, calculation of energy bill and develop awareness on energy conservation to save money in meaningful manners.

The procedure of conducting the learning activities in the developed educational computer game is shown in Figure 1. It consists of six stages as follows:

Stage 1: The objectives of the learning activities are introduced to the students, such as the students should be able to identify the factors that effect on electrical energy consumption in electrical appliances; calculate the energy consumption and cost for operating daily used household electrical appliances; and inculcate better sense of awareness on the energy conservation. Before participating in the learning activities, they are asked to check their prior knowledge on electric energy consumption. Moreover, the rules and basic functions of the game are also demonstrated.

Stage 2: The students receive the simulated situation in which they are encouraged to investigate the cause of power consumption. The teacher will guide them with questions, for example what kinds of electrical appliances operated at your home and how much energy is consumed by those appliances. In this stage, teacher will link students' prior knowledge to the learning activities.

Stage 3: The students receive the first computer game in which they are asked to investigate the energy consumption factors in electrical appliances. This game is divided into two cases. In the first case, the students are asked to select electrical appliance with different wattage and then select the time to compare the energy consumption. Suddenly, the graph of energy consumption will be displayed based upon selected appliances with selected time. The system will guide them to observe the displayed graph to identifying the first factor "wattage" for energy consumption in appliances, as shown in Figure 2(a). Similarly, in the second case, the students are asked to select time for each electrical appliance which has the same wattage to compare the energy consumption. Suddenly, the graph of energy consumption will be displayed based upon selected appliances with different time. The system will guide them to observe the displayed graph to identifying the second factor "time/duration" for energy consumption in appliances, as shown in Figure 2(b).

Stage 4: The students are asked to summarize their finding from Stage 3. The system will guide them to explain the relationship among wattage, voltage, current and time. If they explain incorrectly, the system will show hints and guide them with the displayed graph in Stage 3 once again. Moreover, the teacher will provide meaning of electrical appliance rating, formula for calculating energy consumption of each appliance and also the monthly electric bill in more details.

Stage 5: The students receive the second computer game for applying the constructed knowledge from Stage 4 to new situation. The game is provided with the scenario of home comprising of electrical appliances. Here students are asked to use the electrical appliance(s) with the time limitation for saving money on power bill as much as they can, as shown in Figure 3. If the students fail to save money meaning that they pay much than their income, the system will provide them with hints about the detailed factors of energy consumption.

Stage 6: The students receive the third computer game, that is, to evaluate their own conceptual understanding about energy consumption and awareness of energy conservation, as shown in Figure 4. Once they have finished shopping electrical appliances with the time limitation, the system will show the game result regarding to the different ways for making the appliances more energy efficient.

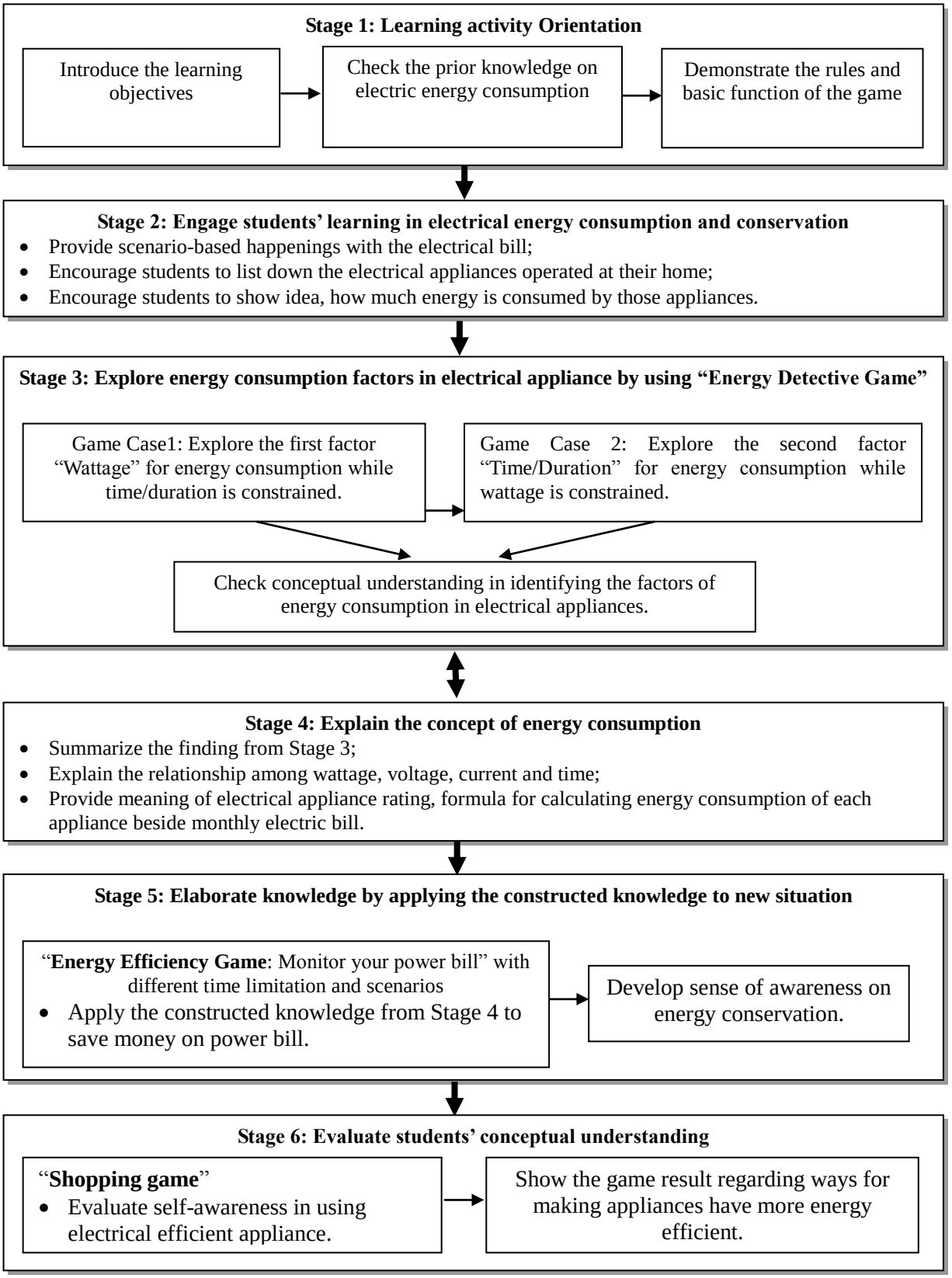
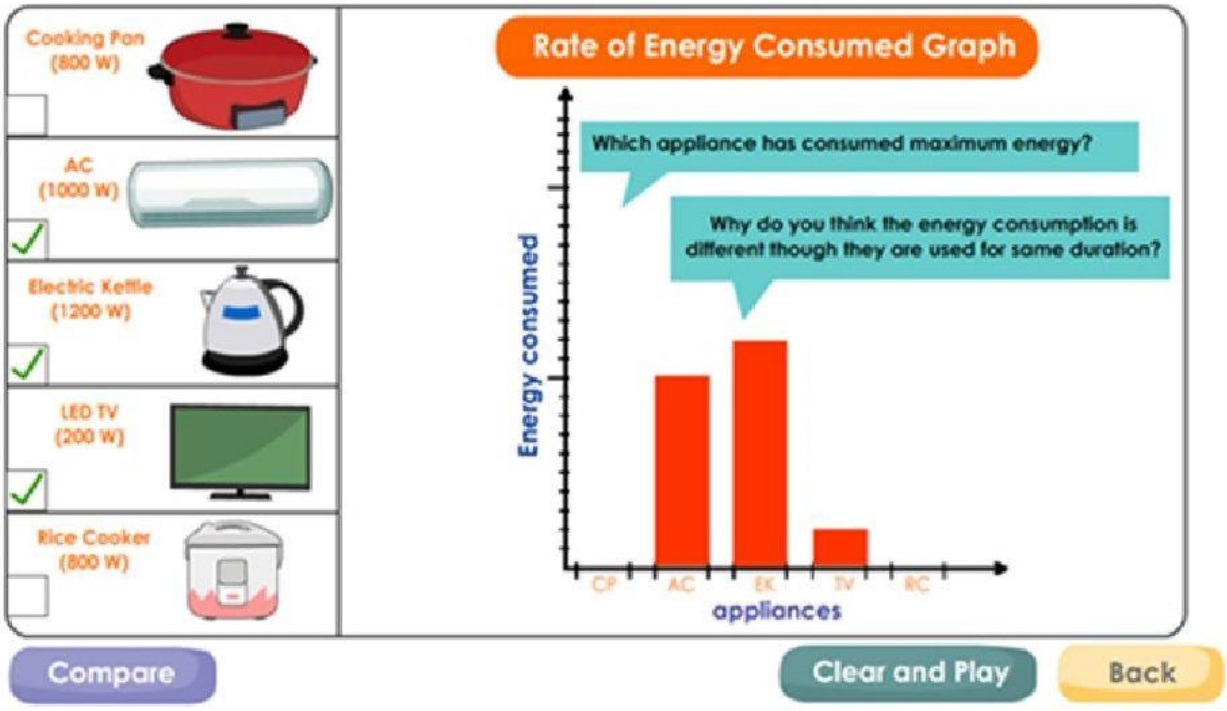
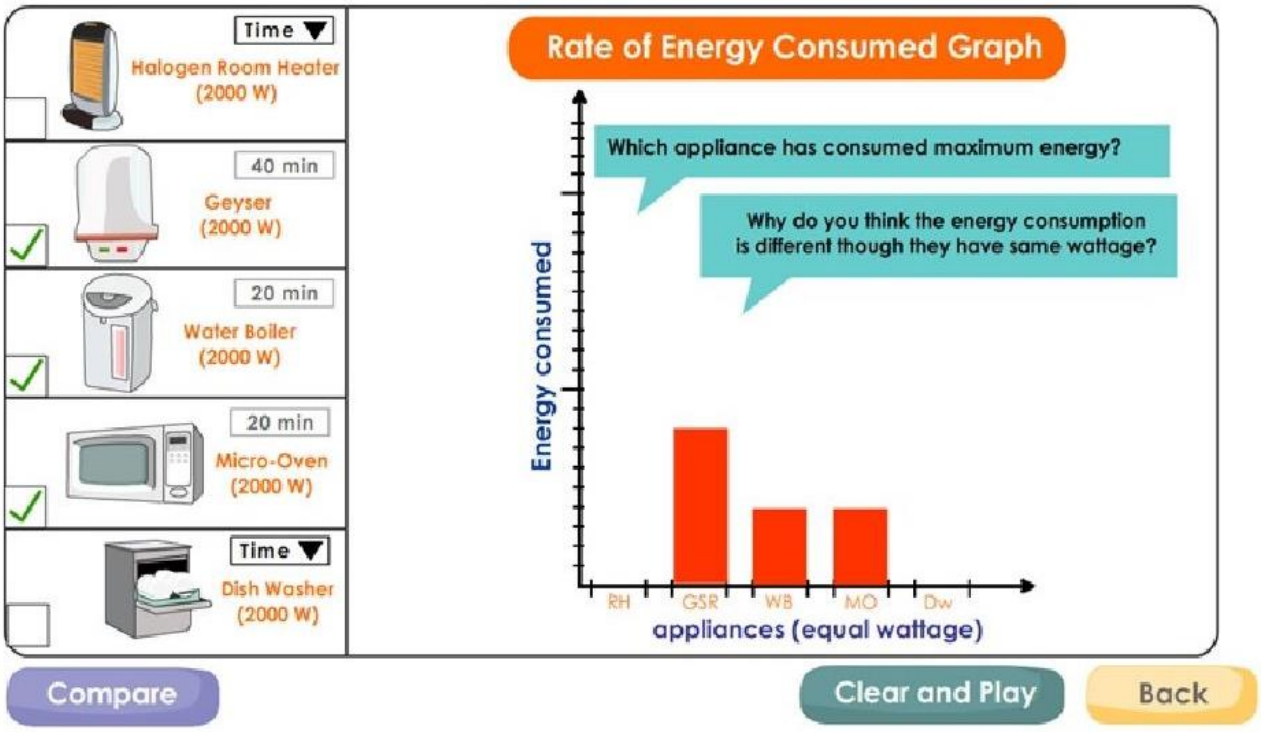


Figure 1. Procedure of the game-based conceptual construction with the 5E learning cycle model



(a) Game case 1: Finding the first factor



(b) Game case 2: Finding the second factor

Figure 2. Explore energy consumption factors in electrical appliance by using "energy detective game"

Experiment design

Participants

To evaluate the effectiveness of the developed computer game based on the 5E learning cycle model, an experiment was conducted on a secondary school energy consumption and conservation topic. The participants of this experiment were four classes of tenth graders secondary school in eastern Bhutan. A total of 129 students participated in this study. Two classes were assigned to be the experimental group, and the others were the control group. The experimental group included 69 students (31 males and 38 females), while the control group had 60 students (32 males and 28 females). In this study, the same teacher taught the students in the four classes in order to avoid the influence of different experienced teachers on the experimental results. The students in control group learned with the lesson in traditional teaching approach based on 5E learning model supplemented by text books, while those in the experimental group learned with the same lesson supplemented by the developed computer game based on the 5E learning cycle model.

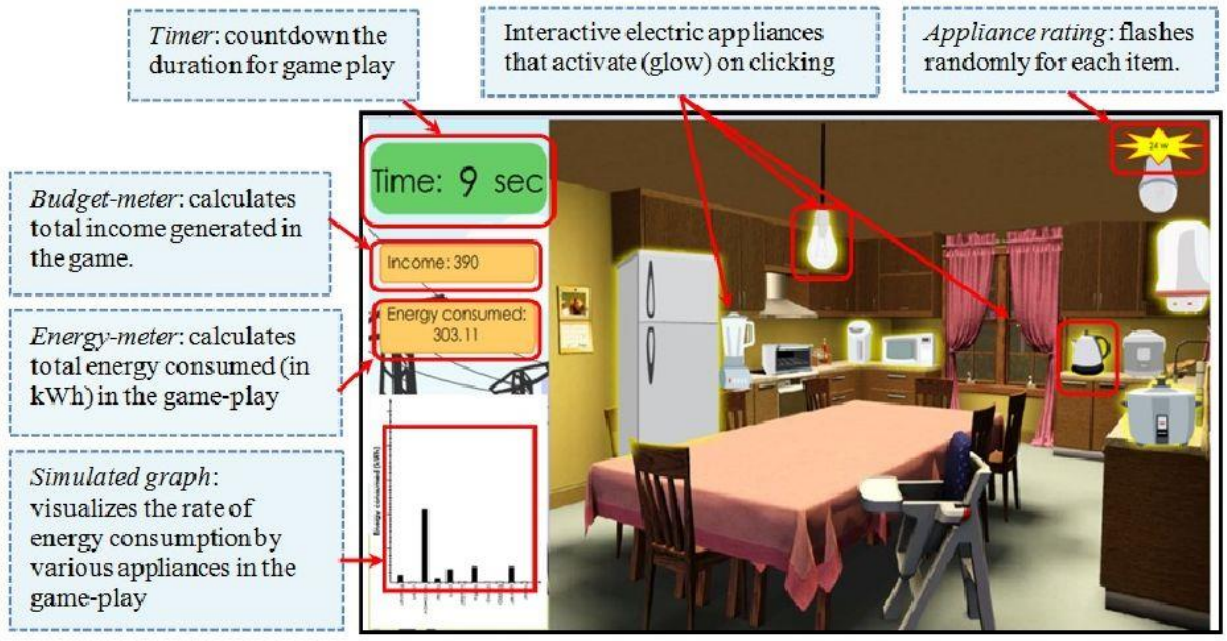


Figure 3. Elaborate knowledge by using "energy efficiency game"

Research tools

To answer the research questions of this study; a pretest, a posttest, a pre-awareness questionnaire, a post-awareness questionnaire, a questionnaire for measuring the satisfaction toward the developed computer game were implemented as the research tools. Both the pretest and the posttest were designed by three experienced teachers. Each test contained 20 multiple-choice items, and one point was scored for each correct answer; therefore, the total score of the tests was 20. The pretest aimed to evaluate the students' prior knowledge of the energy consumption and conservation content. On the other hand, the posttest aimed to evaluate the learning achievement of the students after participating in the learning activity.

The pre-awareness questionnaire is the same as the post-awareness questionnaire. The awareness questionnaire was adapted from Kang, Cho and Kim (2012). It consisted of fifty items on a 3-point Likert scale in which "3" represents "know very well," "2" represents "know some of them," and "1" represents "don't know at all." The Cronbach's alpha value for the awareness questionnaire was 0.99, indicating good reliability in internal consistency.

The questionnaire of satisfaction for the developed educational computer game was used to evaluate the game-based learning with the 5E learning cycle model after the experiment. There were 18 items in three dimensions of the questionnaire: interest (two items), participation (three items), and satisfaction (thirteen items). This questionnaire was measuring using a 5-points Likert scale. The Cronbach's alpha value for the satisfaction questionnaire was of 0.877, showing good reliability in internal consistency.

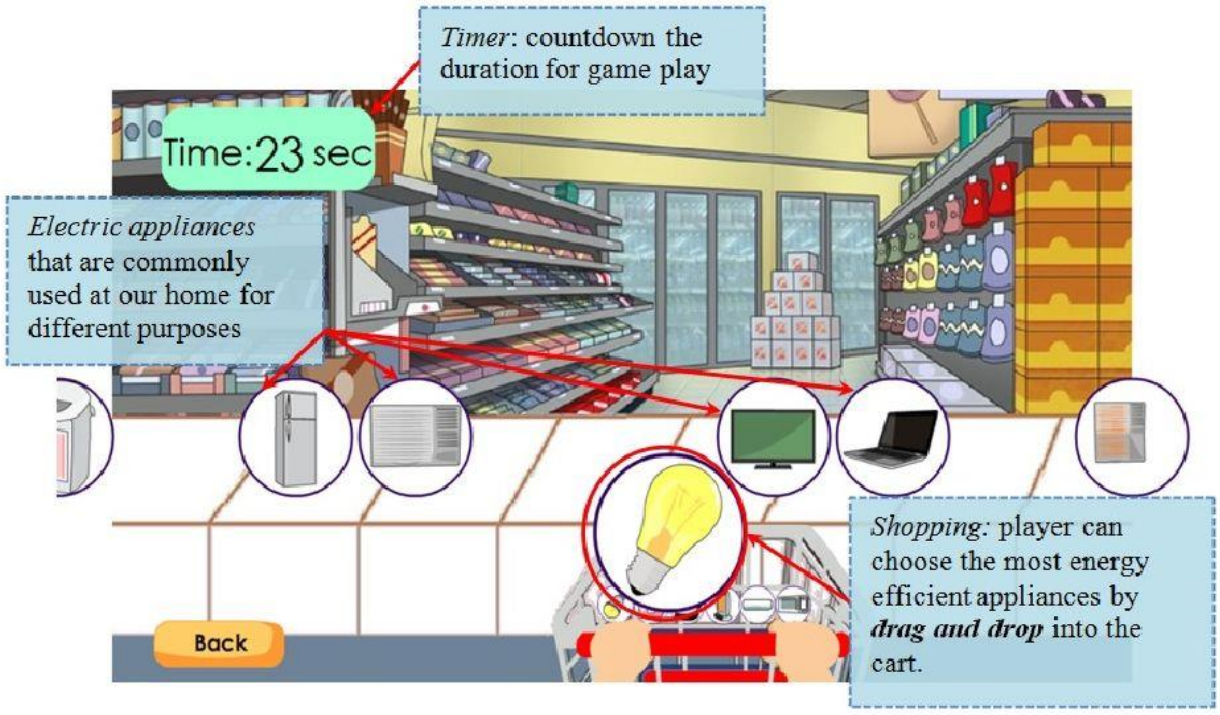


Figure 4. Evaluate students' conceptual understanding by using "shopping game"

Experimental process

The experiment was conducted on the "energy consumption and conservation" unit of a secondary school physics course, which aimed to teach the students understanding of the main factors of electrical energy consumption in electrical appliances, calculating the energy consumption and cost of operating daily used household electrical appliances, and inculating sense of awareness on the energy conservation.

Before the experiement, the students took the pretest for evaluating their prior knowledge of the energy consumption and conservation; moreover, a pre-awareness questionnaire was conducted. The learning activities lasted 90 minutes. The learning content for both the experimental and control group was the same. The students in experimental group learned the content supplemented with the developed educational computer game-based on the 5E learning cycle model, whereas those in the control group were taught with conventional teaching method supplemnetd with text book. After learning activity, a posttest was conducted; morever, the students were asked to response the post-awareness questionnaire again. In addition, the students of the experiemntal group completed the satisfaction questionnaire.

Experimental results

Students' achievement

Before conducting the inferential statistic tests, we found that pre-test scores from both the control group and the experimental group were normally distributed by Shapiro-Wilk test of $p > 0.05$. Therefore, the use of *t*-test was

appropriate. It was found that the mean ± standard deviation of pretest of the experimental group was 7.52 ± 2.244, and of control group was 7.61 ± 2.289. There was no significant difference between the mean score of pretest of the control and the experimental groups (t = 0.230, p = 0.409), indicating that the students in both the groups had similar prior knowledge/concept regarding energy consumption and conservation.

In order to explore the effect of each treatment, another analysis was made to compare the learning improvement of the students in the two groups (i.e., Control and experimental groups). Before conducting the inferential statistic test, in control group, the normal distribution of pre- and post-test scores was tested. We found that the pretest scores were normally distributed by Shapiro-Wilk test (p = 0.156) but the posttest scores were not normally distributed as indicated by Shapiro-Wilk test (p = 0.021). Similarly, in the experimental group, the pretest scores were normally distributed by Shapiro-Wilk test (p = 0.148), whereas the posttest scores were not normally distributed by Shapiro-Wilk test (p = 0.002). Therefore, we deal with non-parametric hypothesis test, Wilcoxon test is used to analyze the pre- and post-test results as shown in Table 1. The results of the learning improvement (posttest *vs* pretest) were significant in both the control group and the experimental group. It is clear that the students in the two groups improved their learning achievement after participating in both the traditional learning activity and the developed learning activity.

Table 1. Wilcoxon result of the pretest *vs* the posttest

Group	*N*	Pretest	*N*	Posttest	*Z*	*p*-value
Control group	60	7.52 ± 2.244	52	10.08 ± 3.330	3.775	0.000*
Experimental group	69	7.61 ± 2.289	69	11.97 ± 3.839	6.091	0.000*

*$p < 0.05$.

Furthermore, to examine how the learning achievement was affected by the treatments after the implementation of the developed learning unit, the posttest scores of both control and experimental groups were analyzed with non-parametric hypothesis test, Mann-Whitney U test, as shown in Table 2.

Table 2. Mann-Whitney U result of the posttest

Groups	*N*	Mean ± *SD*	*Z*	*p*-value
Control group	52	10.08 ± 3.330	2.537	0.005*
Experimental group	69	11.97 ± 3.839		

*$p < 0.05$.

The result in Table 2 shows that there is significant difference of the posttest scores between the experimental group and the control group. In other words, the mean score of posttest for the experimental group were significantly higher than that for the control group, suggesting that the developed educational computer game based on the 5E learning cycle model could enhance better the learning achievement in energy consumption and conservation unit.

Energy conservation awareness

Table 3 shows the descriptive statistics and *t*-test of the pre-awareness survey, it shows that students have fairly good ideas about the awareness on energy conservation such as "awareness on heating rooms with minimum energy lost (heating room)," "awareness on using different electrical appliances for cooling rooms (cooling)," "awareness on daily life habits in operating household appliances to minimize energy conservation (household appliances)," but they had comparatively lower awareness about the "awareness on windows insulation with minimum energy(window)," "awareness on lighting rooms for less energy consumption (Lighting)," "Awareness on buying electrical appliances looking into Energy Star Rating for it energy efficiency (Energy Stars)." When classifying this into groups, the results suggest that the students in both the groups had similar level of awareness towards energy conservation. Statistically, there is no significant difference in students' pre-awareness on energy conservation in both groups except in term of the "cooling" factor, indicating that students in the control group had exhibited better awareness in term of using electrical appliances for cooling rooms than that those in experimental group. This might be because of the students in the experiment group might not have experienced with those appliances that are utilized for cooling the rooms which are especially operated in hot environments.

Table 3. Comparison of students' pre- awareness on energy conservation

Awareness	Mean (*SD*)	Control Group	Exp. Group	*t*	*p-value*
Window: Awareness on windows insulation with minimum energy lost	1.80(0.31)	1.85(0.32)	1.76(0.31)	1.63	0.052
Room Heating: Awareness on heating rooms with minimum energy lost	2.11(0.44)	2.17(0.43)	2.05(0.44)	1.53	0.065
Cooling: Awareness on using different electrical appliances for cooling rooms.	2.01(0.46)	2.09(0.43)	1.92(0.53)	1.93	0.028*
Lighting: Awareness on lighting rooms for less energy consumption	1.96(0.58)	1.88(0.58)	2.04(0.57)	1.57	0.060
Household Appliances: Awareness on daily life habits in operating household appliances to minimize energy conservation	2.05(0.31)	2.08(0.32)	2.02(0.30)	1.05	0.149
Energy Stars: Awareness on buying electrical appliances looking into Energy Star Rating for it energy efficiency	1.91(0.70)	1.87(0.72)	1.95(0.67)	0.61	0.272

*$p < 0.05$.

Table 4 shows the students' level of awareness on energy conservation who participated in two different interventions; it advocates that overall students' consciousness on electrical energy conservation had enhanced after taking part in this study. The results also reflected that the students in experimental group exhibited better awareness than those in control group. Moreover, it indicates that students in experimental group shows significantly higher level of awareness/consciousness about electric energy conservation, such as in "awareness on daily life habits in operating household appliances to minimize energy conservation (household appliances)," "awareness on buying electrical appliances looking into Energy Star Rating for it energy efficiency (energy stars)," and "awareness on lighting rooms for less energy consumption (lighting)" than those in control group. These are the common factors that contribute majorly in saving energy in our daily life. Statistically, there are significant differences of post-awareness on energy conservation between students in the experimental group and the control group. These results confirms that the developed educational computer game based on the 5E learning cycle model is able to promote students' awareness on electric energy conservation, particularly in buying and using daily household appliances in their life as to save money in long time.

Table 4. Comparison of students' post-awareness on energy conservation

Awareness	Mean (*SD*)	Control Group	Exp. Group	*t*	*p-value*
Window: Awareness on windows insulation with minimum energy lost.	2.55(0.40)	2.48(0.44)	2.62(0.37)	-1.97	0.03*
Room Heating: Awareness on heating rooms with minimum energy lost	2.43(0.40)	2.36(0.42)	2.50(0.39)	-1.95	0.03*
Cooling: Awareness on using different electrical appliances for cooling rooms.	2.50(0.47)	2.41(0.58)	2.60(0.36)	-2.19	0.02*
Lighting: Awareness on lighting rooms for less energy consumption.	2.66(0.46)	2.56(0.58)	2.75(0.34)	-2.38	0.01*
Household Appliances: Awareness on daily life habits in operating household appliances to minimize energy conservation.	2.56(0.31)	2.53(0.36)	2.60(0.26)	-2.93	0.00*
Energy Stars: Awareness on buying electrical appliances looking into Energy Star Rating for it energy efficiency.	2.47(0.51)	2.40(0.62)	2.54(0.41)	-2.51	0.01*

*$p < 0.05$.

Satisfaction with the educational computer game

Table 5 shows the descriptive statistics of the satisfaction questionnaire. Overall analysis from the questionnaires reveals that the students have rated "high satisfaction" for the developed computer game-based learning for being able to develop interest in learning the concept of electrical energy consumption and conservation. Moreover, the students stated that they were "highest satisfaction" towards the developed computer game based on the 5E learning cycle model as it had encouraged them to participate in the learning activities through its interaction; in addition, the students rated that they have "high" level of satisfaction in learning concept of electrical energy consumption and conservation through the developed educational computer game.

Table 5. Students' satisfaction about the developed educational computer game

	Satisfaction	Mean	*SD*	Remark
Interest	I enjoy physic lessons very much with computer game.	4.27	0.78	High satisfaction
	I become more curious and observant in the class when the lesson is integrated with computer game.	4.39	0.76	High satisfaction
Participation	I enjoy participating in class activities when the lessons are taught using computer game.	4.45	0.77	High satisfaction
	The lessons using animations, game and simulated activities make me more attentive in the class.	4.56	0.73	Highest satisfaction
	Integration of computer game in the lesson promotes better interaction amongst friends and teachers.	4.33	0.73	High satisfaction
Satisfaction	It is easier for me to understand the content with computer game.	4.45	0.59	High satisfaction
	I get learning satisfaction when I learn the lesson with computer game.	4.38	0.67	High satisfaction
	Computer game in the lesson helps me to develop confidence in learning electrical energy calculation.	4.53	0.75	Highest satisfaction
	I found the graphics and computer game useful in visualizing the concepts.	4.26	0.69	High satisfaction
	Computer game in learning helps me to think and analyze the real things in world.	4.48	0.71	High satisfaction
	It helps me to develop the relevance between the course and real world situations.	4.20	0.85	High satisfaction
	Computer game allows me to develop skills needed in the real world.	4.39	0.72	High satisfaction
	I like the way the teacher uses computer game to teach energy consumption by various household appliance lesson.	4.70	0.58	Highest satisfaction
	The use of computer game in the lesson helps me to build confidence in understanding the concept of energy consumption clearly.	4.32	0.68	Highest satisfaction
	I like computer game in learning electrical energy consumption and conservation sessions because it enables me to learn faster.	4.53	0.71	High satisfaction
	I gain confidence when I learn the lesson using computer game.	4.23	0.65	High satisfaction
	I like electrical energy lessons with computer game because the lessons are interesting, informative and help to visualize the abstract concepts of energy better.	4.48	0.71	High satisfaction
	I like computer game technology integration in all the subjects to help enhance our critical thinking.	4.30	0.84	High satisfaction

Discussion

This study was conducted to examine the effectiveness of two methods of learning electric energy consumption and conservation (computer game based on a learning cycle approach and conventional teaching approach) for secondary school students. The results of this study revealed that the learning cycle-based computer game group significantly outperformed the conventional group in understanding main factors of energy consumption in electrical appliances, calculating the energy consumption and cost of operating daily used household electrical appliances, and inculating sense of awareness on the energy conservation. Possible reasons for this observed difference might include the value related with alternative ways of acquiring and constructing knowledge in the topic, particularly exploration, and elaboration. During the educational game, students learned through their own actions and reactions by being involved in gamified activities. They explored the energy consumption factors in electrical appliances and the graphical responses from simulating the energy consumption encouraged them to identify the correct factors. Students' explorations involved trying out and learning from errors for saving money on power bill as much as they can. They were also involved in gamified activities that helped them to examine the adequacy of their conceptions and encouraged them to discuss about those conceptions. This led to the opportunity to construct more appropriate concepts and develop energy conservation awareness. Meanwhile, students in the conventional teaching group mainly focused on concepts related to the topic, the process that required less conceptual restructuring.

The findings of this study showed that the developed educational computer game provided higher level of learning achievement, awareness and satisfaction for students. This was consistent with various studies that advocated the correct use of the learning cycle instruction accomplished both effective learning of concepts and an ability to apply concepts (Piyayodilokchai et al., 2013; Yadigaroglu & Demircioglu, 2012) and with the study that used a game-based learning strategy to encourage learners to conserve home energy usage (Yang et al, 2012). Moreover, during involving in gamified activities, they become aware of their own ideas, beliefs and attitudes by using the simple tasks which is related to everyday tasks or phenomena (Ebenezer, Chacko, Kaya, Koya, & Ebenezer, 2010). Therefore, the students are engaged and motivated via direct experiences. In other words, it was also suggested that developing usable educational technology showed a more seamless learning experience (Slotta & Najafi, 2012).

However, there is no report of the study that applies the 5E learning cycle model in developing an educational computer game. So this study may provide a useful guideline to further the development of a computer game based on the 5E learning cycle model.

Conclusion

The result of this study indicated that the use of educational computer game embedded with the 5E learning cycle model is an alternative teaching and learning method to traditional instruction and could be used to promote meaningful learning in electric energy consumption and conservation. From the effective learning outcomes of this study, we recommend a set of guidelines for any practitioner/teacher/instructor as follows:

- The lesson is introduced with the scenario-based, so teacher(s) should emphasis on the objective of the scene with further explanation to develop curiosity for learning the lesson (e.g. "Why monthly electric bill is more?"). This should not take more than 5 minutes.

- Participants should be instructed to follow the learning modules in sequence as Energy Detective, Energy Efficiency Game, and Shopping Game. The time allocation for these activities is assigned for 50 minutes tentatively as to suit the time needed by the students for different activities depending upon the ability of the students.

- At the end of each phase, the teacher(s) need to provide participants opportunities to share and explain their understanding of the concepts, skills and processes they are learning. In the meantime, teacher(s) should take opportunities to clarify students' misconceptions and help them in introducing new concepts, process and skills. Moreover, teacher(s) should challenge and extends students' conceptual understanding and skills of the concept by conducting additional activities that focuses on adding breadth and depth to current understanding.

- The learning process is vital aspect of the developed supplemented instructional unit. Therefore, designing a formative assessment that suits the students' background and learning environment to follow students learning process to help in evaluating more authentic learning outcomes are required.

Beside the mentioned points, it is always advisable that teachers/practitioners inform the students about the learning process of the instructional unit before the implementations, as the new type of teaching and learning approach might not be familiar for some students in some schools. This would minimize confusion and time wastage, and eventually help in setting good flow while implementing the learning unit. Still if any teachers/instructors/practitioners having difficulty in executing the teaching and learning activities related to gamified intervention embedded with 5E learning cycle model, the authors will be willing to provide a guided lesson plans, a manual of the game or technical assistance upon request. Moreover, to be generalization, it should as well be studied more on a large number of students with different backgrounds before being adopted for wider use.

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