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Sufficiency Economy Philosophy-Based Mobile Game Application to Promoting Sustainability Understanding based on Inquiry Learning with Everyday Life Activities

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Abstract: His Majesty King Bhumibol Adulyadej's Sufficiency Economy Philosophy (SEP) has been named as a way of life for sustainability. In Thailand, SEP has been included in the basic education core curriculum to learn about efficiency life, reasonably and meticulous. However, the teaching of SEP only focuses on memorization with a limited example, resulting in students' poor understanding and are unable to apply to their daily lives. With the advantages of mobile devices, this study developed a mobile game application to address such learning flaws and enhance the understanding of sustainability through the game missions of everyday life activities. The mini game stories were carefully designed with the scenarios, situations, and missions in corresponding with SEP pillars of moderation, reasonableness, and protection. Students play and learn the topic by following the inquiry-based learning approach. In addition, a quasi-experiment was conducted with primary school students in Social Study course to investigate the effectiveness, perceptions and cognitive loads of the developed game application. The findings reveal that the students who learned with the proposed game could outperform than those who learn with the traditional e-learning with no interactive activities; meanwhile, it found that those who got the high achievements performed well during the learning process with the shorter time on the developed game. Furthermore, the high achievers reveal better perceptions towards the game than the students with low success and felt not difficult to experience this new learning platform. In other words, this developed mobile game is helpful for students to improve their understanding of sustainability for efficiency life and society.

Keywords: Sufficiency Economy Philosophy, sustainability, social study, inquiry learning, mobile learning, educational game

1. Introduction

In the past decades, human society has changed rapidly according to the changing world regarding economy, culture, politics, and environment. Especially, the dissipation can cause many social problems. UNESCO's National Economic and Social Development Plan has contained the sufficiency economy as a guideline in administering the country in seeking for the sustainability in human lives since eighth edition (Piboolsravut, 2004; Pruetipibultham, 2010). Since then, many countries all over the world have taken these concerns into account and have developed many policies and strategies to promote the sustainability in various dimensions ranging from a country scale, a society scale, to a household level.

In 1974, His Majesty King Bhumibol Adulyadej initiated Sufficiency Economy Philosophy (SEP) as a way of life for sustainability. It comprises three core pillars (moderation, reasonableness, and protection). Such philosophy has widely been accepted and applied in various context worldwide

(Jairak, Praneetpolgrang, & Subsermsri, 2015; Rungwitoo, 2013; Unger, 2009). Furthermore, SEP has been included in the Basic Education Core Curriculum B.E. 2551 (A.D. 2008) in Thailand to teach students about life's efficiency, reasonableness, and meticulosity. However, the present teaching only focuses on memorization, which causes boredom and doesn't motivate students to learn; meanwhile, the application in the agricultural context is most often used as an example. Therefore, students do not understand SEP and cannot apply the knowledge into their daily lives for sustainability (Jairak et al., 2015).

In the past years, smartphones have become accessible in many schools, while many useful applications can help enhance and improve the learning. The interaction on the touch screen can help motivate learning and improve the learning performance. Moreover, the game apps are widely popular for the children as they are simple to play, interesting and exciting to children (Daungcharone, 2016). The children enjoy playing games and learning along the way if the knowledge is added. In the meantime, game-based learning has become significant as a medium in teaching and learning that designs and incorporates lessons in the game which allow students to engage in learning, playing and practicing during the learning (Pareto, 2014).

To address the abovementioned issue, we developed a mobile game application to promote students' sustainability understanding based on SEP. Every day's life activities in different situations were used in the game missions to help students link their personal experiences with the core pillars of SEP. Moreover, game stages were designed based on the inquiry learning process of 5 Essential Features on Inquiry, while the game learning experience was considered based on game-based learning strategy. The game story design has been confirmed by experts before the actual development. While playing, students travel to different situations, talk with nearby people, and enjoy the game missions with their interactions to enhance understanding of sustainability; accordingly, a meaningful learning feedback is provided upon the learning performance.

Therefore, to investigate the effectiveness of the developed game, an experiment has been conducted with primary-school students in a Social Study course to answer following research questions:

- Do the students who learned with the developed game have a better understanding of sustainability compared to those who learned with the traditional e-learning?
- What is the learning performance during the learning process of the students who learned with the developed game?
- What are their perceptions and cognitive loads towards the developed game?

2. Related Studies

2.1 Sufficiency Economy Philosophy (SEP)

Sufficiency Economy Philosophy (SEP) was developed based on the fundamental of Thai culture by His Majesty King Bhumibol Adulyadej in 1974. It is a model that encourages Thai people to live with moderation, prudence, and social immunity (Supadhiloke, 2013). The SEP is widely valued among Thai people. It is necessary to study the principles and concepts to understand it correctly in order to be applied appropriately to the societal living for sustainability. SEP can be applied to individual daily life in every time at all levels.

SEP is described with the following three pillars. 1) Moderation: Sufficiency in a way that is not too much or too little, according to its own ability and not distort the other, 2) Reasonableness: Decide carefully and think about the consequences of the action, and 3) Protection: Readiness for preparing for possible risk management both for themselves and others (UNESCO, 2013). When applying the three pillars, the effect will be balanced and get ready to change quickly and widely in all dimensions both of social, environment and cultural assimilation (Malikhao, 2017; Sornsri, 2016; Supadhiloke, 2013). For example, Phanchan (2009) found the SEP is a principle that is flexible in practice and practicable to all areas and situations, while Coskun, Zimmerman and Erbug (2015) revealed that living under SEP can make silence and peace. The people who insist with SEP life can away from hunger and have the right to political freedom (Elinoff, 2016). In public health, the sufficient life can make people healthy as reported by Arpanantikul, Phuphaibul and Khuwatsumrit (2017).

Based on SEP benefits on promoting sustainability in life, the authors adopt the principles of three pillars as a developing framework in this study.

2.2 Inquiry-based Learning with 5E Learning Cycle

The principle of the Five Essential Features of Inquiry (5EFI) is an instructional activity based on the inquiry learning process in order to enhance students to create self-learning experiences, reasonable and have the ability to invest knowledge using scientific processes. Bybee and Landes (1988) characterized five steps of the inquiry-based learning process as follows. 1) Engagement: It is an introduction to a lesson or a topic which arises from doubt, is a motivator for students to create a set of questions, 2) Exploration: Exploring, searching, experimenting hypothesis to determine possible information, 3) Explanation: To summarize and to present the results, 4) Elaboration: To bring the knowledge linked to prior knowledge or experiences in order to explain events, and 5) Evaluation: To evaluate learning processes and to apply knowledge to other situations.

The process of 5EFI helps students learn effectively in various context. For example, Renken, Peffer, Otrel-Cass, Girault and Chiocarriello (2016) used 5E and project-based learning to encourage learning challenges and to enhance the understanding of the scientific skills and found that students can answer in-depth and expressive questions that demonstrate the understanding of the concept. Pareto (2014) used the 5E process to understand the reasoning in mathematics, which concluded that it could help achieve deeper levels of learning that transfer outside the game.

By these reasons, the 5E inquiry learning approach was applied in delivering stories and situations as game stages to provide the meaningful and efficient instruction.

3. Game Story Design to Promoting Sustainability Understanding

In order to best promote the understanding of sustainability on mobile learning environment, the game story has been designed into three stages. Each stage incorporates with two designated game missions for a certain situation in corresponding to daily-life activities. Each mission is expected to provide a concrete understanding on at least one of the SEP pillars. Figure 1 illustrates the overall game story design as follows:

- Stage 1: The activity in this stage is self-occurrence as to visit the grand mom's house with the humid condition. Taking a bath, hair wash, and toothbrush, and selecting appropriate clothes are the missions to gain the practical understanding of protection to preventing dirt and unhealthy substances onto the body, and reasoning of appropriateness at particular time and condition, respectively.
- Stage 2: Happening in the family at the grand mom's house, the missions of sufficient eating and selecting the right tools for gardening are responsible for following SEP pillars, i.e. sufficiency upon individual requirements, and reasoning to avoid the damage of improper selection of tools.
- Stage 3: This stage represents the story at a local market as part of the society. The mission of buying eggs by considering their quality at the lower price is to promote the moderation; while, the task of selecting apples by considering their freshness, cleanness and pest-free for healthy conditions of self and others is to encourage both reasonableness and moderation.

In addition to each game mission, the avatar (representing the player) can communicate with the person in that given situation to lead in the story more meaningfully, naturally, e.g. having a conversation with dad as looking for the gardening tools before selecting them in a mission. Furthermore, the whole game story from situations, missions, stages to the integration with SEP has been cross-validated by three experienced scholars on SEP, three people who have been applying SEP into lives for years, and three experts on game mechanics and design. This confirms a meaningful learning experience of promoting sustainability in a mobile game environment.

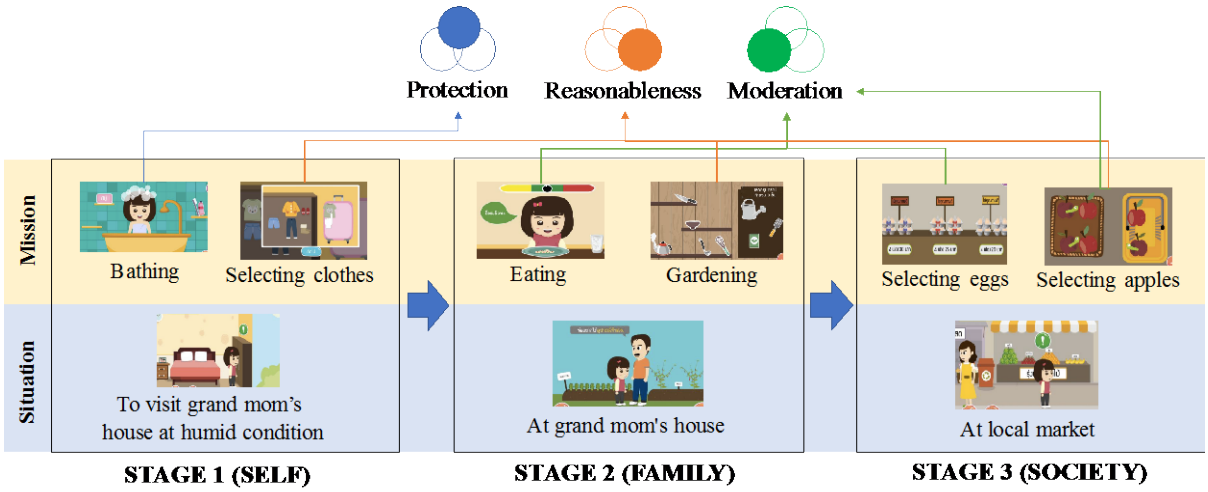

Figure 1. An Illustration of Game Story Design.

4. Game Development

As game and story already been designed in the previous section, the overall game application has been constructed following 5E inquiry learning approach into four modules, plus one extra module for data recording. Therefore, there are five main modules in the developed game, as the overall structure presented in Figure 2. The game was developed with Personal Edition of Unity and built as a mobile application for Android devices, hereinafter called TheLittleSatis. The detailed description and learning process of each module is explained in Table 1.

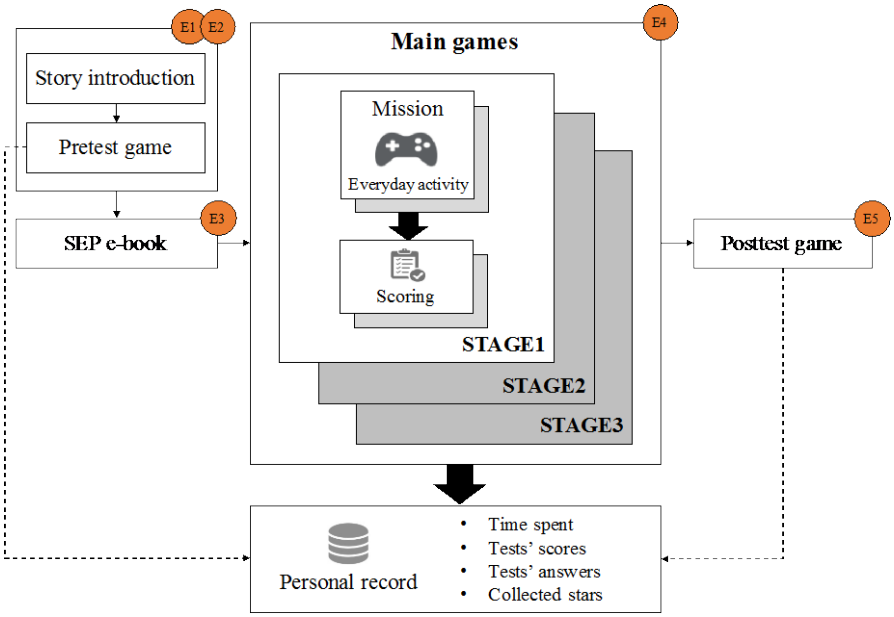

Figure 2. An Overall Structure of TheLittleSatis.

While the student is experiencing the game, the additional module, called Personal record, analyzes the learning performance on each game mission not only for recommending the ongoing feedback, but also for providing the learning summary, including time spent, pre-/post-test scores, and collected stars, as shown in Figure 4D. In each game mission, the scoring mechanism is account for 1) emoticon feedback by checking if the corrected interactions/answers over 50%, smiling feedback is given; otherwise crying feedback, and 2) collected stars in which each star represents 33.33% interactions/answers' accuracy.

As a result of game development, TheLittleSatis has been piloted with a small group of students and suggested by abovementioned nine experts for the final improvement. Hence, the developed mobile game is ready for the experiment.

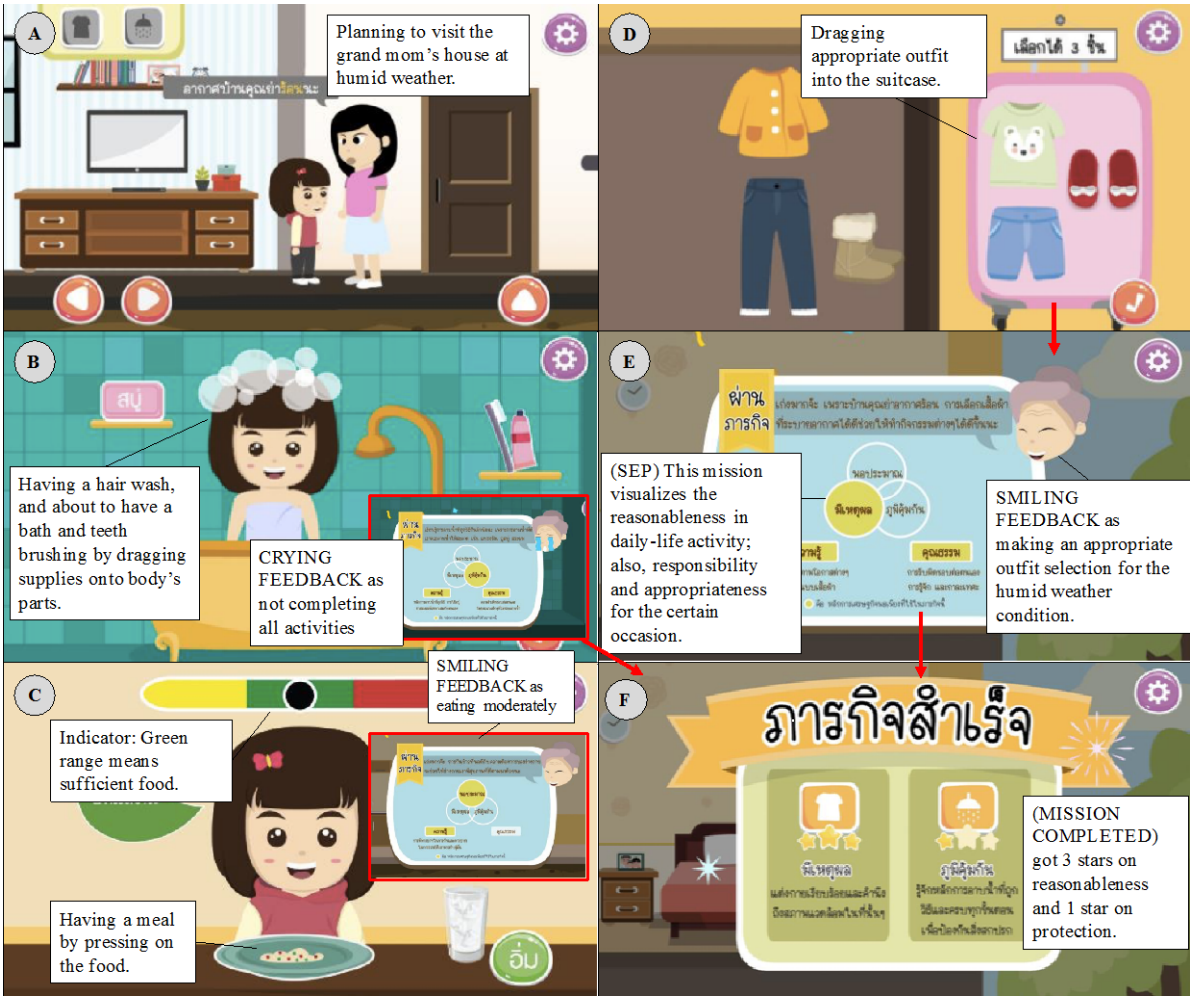

Figure 3. Example Screenshots of Main Games.

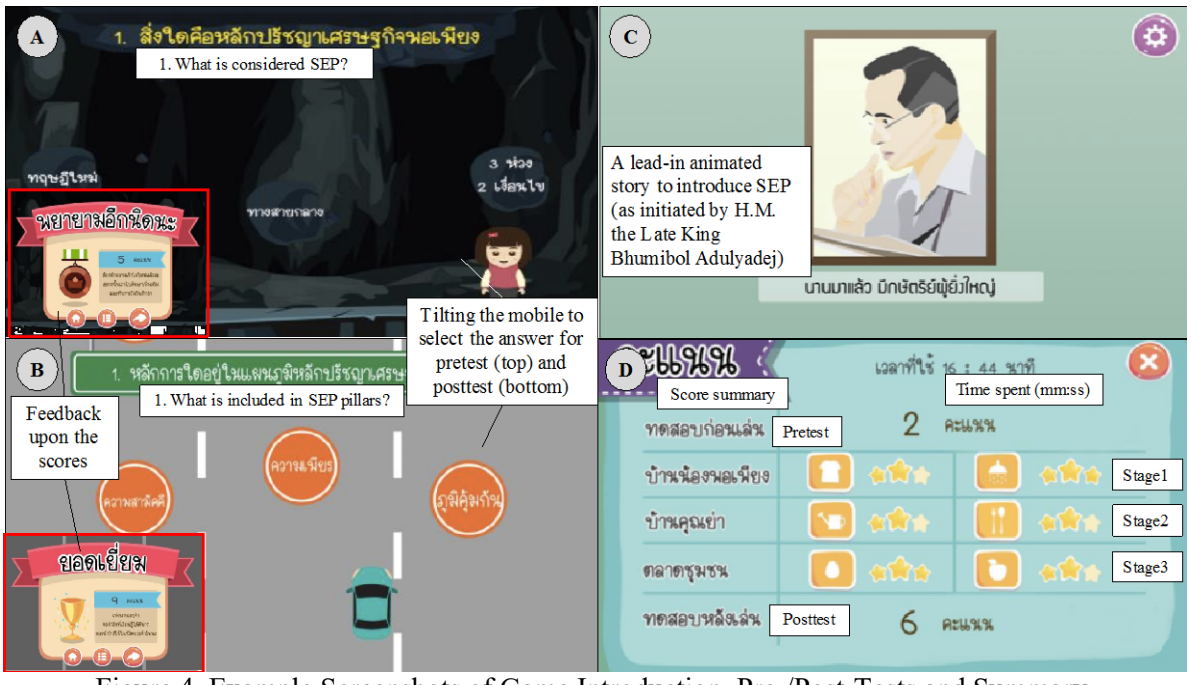

Figure 4. Example Screenshots of Game Introduction, Pre-/Post-Tests and Summary.

Table 1: Detailed explanation of game modules and learning processes.

Module	Description	Inquiry Learning Process
Module 1 (E1, E2)		
Story Introduction	As a mini-game, the student learns to control the avatar via the walk-through game story introduction by pressing the button for the desired direction of the avatar, while get acquainted with the game environment, e.g. scenes, decoration, obstruction, and interaction.	This initial activity of the game is designed to engage students in the game, story and the significance of sustainability in SEP. Besides, the student can explore the game introduction.
Pretest game	As shown in Figure 4A, the student tilts the mobile device to move the avatar to collect the correct response upon the SEP-related items as a warm-up activity. In the end, the game gives encouragement popup upon the prior performance.	
Module 2 (E3)		
SEP e-book	As shown in Figure 4C, the student can swipe each page of an e-book on screen as learning the theory in easy-to-understand infographic format presentation. The voice and subtitle narration are provided for better perceptions while the effect sound makes the learning alive.	The student is explained the basic knowledge of SEP theory starting from the history to the everyday activity. This makes the connection between the student's prior knowledge and the following learning activities.
Module 3 (E4 – selected main games)		
Mission1 from Stage1	Figure 3A, the avatar has some conversation with the mom ahead of visiting the grand mom's house by moving the avatar to meet the mom. The student then walks to the bathroom. Figure 3B, the student drags the soap for cleaning body, shampoo for hair wash, and toothbrush and toothpaste for teeth cleaning. Subsequently, the popup presents the mission feedback with emoticon face and visualizes the knowledge learned in SEP pillar representation; also, morals drawn from the mission.	This mission promotes the understanding of personal immunity for student via the everyday bathing activity, also the knowledge of body hygiene in getting rid of everywhere germs. Note: The ending popup is prompted after each mission according to the mission's performance and relevant knowledge of SEP. This help student to reflect what he/she has understood and either to replay or not for better understanding.
Mission2 from Stage 1	To find the proper outfit for the humid weather condition at the grand mom's house, the student enters the dressing room. This mission requires the student to select three out of six pieces of clothes appropriately by dragging them into the suitcase, as shown in Figure 3D. Figure 3E illustrates the ending popup for this mission.	This mission helps the student understand the personal reasoning in fitting with given situation and condition, also the appropriateness of wearing outfit for the particular occasion.
Mission3 from Stage 2	Having dinner at grand mom's house, the avatar enjoys the meal. As shown in Figure 3C, the student taps food in the dish for eating as the amount of rice is reducing and the level of consumed food is increasing shown above. The student is aware of moderate eating by stopping eating when the indicating scale lands on the green.	The student inquires the knowledge of sufficiency by practicing on every food consumption. Also, the knowledge of the proper manner when having meals with family members is highlighted.

Module 4 (E5)		
Posttest game	As shown in Figure 4B, the student tilts the phone to move the car to collect the accurate response upon the question item. According to the SEP understanding, the popup displays the feedback and encouragement.	Finally, this game helps the student to evaluate the knowledge of SEP and sustainability after experiencing and elaborating on the game.

5. Experiment

5.1 Experimental Design

To evaluate the effectiveness of the proposed game, an experiment has been conducted in comparison with the traditional method. In this study, a quasi-experimental research design has been employed since the participants were not randomly assigned. The experiment was conducted with 140 fourth graders from four classes at a primary school in Thailand. With a simple drawing of the class's representatives, 76 students from two classes were recruited in the experimental group (EG), while 64 students of the other two classes in control group (CG). Note that students from four classes were taught by the same teacher, and each class learned independently due to the school's timetable; moreover, all students have had at least one-year mobile gaming experience.

Within two periods (90 minutes) of Social Studies hours, EG learned from the developed TheLittleSatis, while CG learned from the traditional e-learning. The traditional method required the students to passively learn the similar content of SEP topic in three chapters, each account for one SEP pillar, on the text-based e-book format with some pictures and diagrams; however, there were no any interactive activities presented.

The research instruments used in this study were:

- Pretest and Posttest: each has ten multiple-choice-question items (total score = 10). Pretest and posttest are designed in parallel to examine the understanding of sustainability content learned in both groups. The content validity was approved by three SEP scholars, while the reliability was accepted with Cronbach's α of 0.885.
- Perception Questionnaire: to examine the students' perception towards TheLittleSatis with 26 5-point Likert scale rating items on four dimensions, as shown in Table 4. The students rated each item from 1 (lowest) to 5 (highest). The questionnaire was adapted from Wongta et al. (2016), and Wongwatkit, Tekaew, Kanjana and Khrutthaka (2015) and tested for the acceptable reliability with Cronbach's α of 0.822.
- Cognitive load questionnaire: to examine students' mental loads and mental efforts towards TheLittleSatis with eight 7-point Likert scale items, ranging from 1 (not at all to me) to 7 (very true to me). The questionnaire was adapted from Hwang, Yang and Wang (2013) with Cronbach's α of 0.831.

Both groups (EG and CG) of the students followed the same research process. Starting with the 10-minute orientation, the students were explained for the learning objectives and got acquainted with the materials. The students then took the pretests and experienced the assigned materials by following the embedded instructions and learning activities for 60 minutes. After a short break, the students spent about 20 minutes on post-tests, perception questionnaires, and cognitive load questionnaires; thereby the summary was given by the teacher. Moreover, the authors used the personal learning records from the application for further analysis in this study.

5.2 Experimental Results

5.2.1 Learning Performance

To examine the effectiveness of the proposed game, TheLittleSatis, the students' learning performance of sustainability understanding was analyzed from pretest and posttest's scores. Regardless of the effect of students' different prior knowledge, ANCOVA test was considered by taking the pre-test scores as a covariate. Several assumptions were tested ahead. We found that the standardized residuals for the

interventions were normally distributed, as assessed by Shapiro–Wilk's test ($p > 0.05$). There was homogeneity of variances, as assessed by Levene's test of homogeneity of variance ($F_{(1,138)} = 0.296$, $p = 0.588$). Moreover, there was homogeneity of regression slopes as the interaction term was not statistically significant ($F_{(1,136)} = 0.041$, $p = 0.752$). Therefore, ANCOVA test was performed.

Table 2 shows that there was a statistically difference between two groups of posttest scores ($F_{(1,137)} = 13.452$, $p = 0.000$, $\eta^2 = 0.068$). This implies that TheLittleSatis could help the students to have a better understanding of sustainability.

Table 2: ANCOVA result on students' learning performance.

Group	*n*	Unadjusted		Adjusted		$F_{(1,137)}$	η^2
		M	*SD*	*M*	*SE*		
EG	76	8.641	1.561	8.674	0.147	13.452***	0.068
CG	64	7.432	1.728	7.357	0.162		

****p < 0.001*

In addition to the students' learning performance on TheLittleSatis as analyzed from the pretest and posttest' scores, the collected stars could represent an ongoing understanding of sustainability on SEP core pillars, while the duration used in each mission could tell the confidence on practicing each mission. Median-split technique was performed on students' posttest scores to categorize students into low ($n = 42$) and high ($n = 34$) groups of achievements.

Table 3 shows that high-achieving students could collect statistically more stars than those who had low success in all game stages, meaning that the high achievers learned well in between the game, and resulted in high learning performance. Meanwhile, high achievers spent significant lesser time in all stages than those who had low achievement, meaning that they were confident with the game story.

Table 3: Students' collected stars and duration spent on TheLittleSatis on low- and high- achievement.

Stage	Collected Star (M ± SD)			Duration in seconds (M ± SD)		
	Low (n = 42)	High (n = 34)	*t*	Low (n = 42)	High (n = 34)	*t*
1	1.559 ± 2.144	2.275 ± 1.633	1.381*	454.230 ± 1.454	418.130 ± 0.897	126.502***
2	2.014 ± 1.775	2.832 ± 1.832	1.969*	426.090 ± 1.887	394.540 ± 1.433	80.466***
3	1.708 ± 1.401	2.365 ± 0.966	2.322*	537.110 ± 1.124	530.320 ± 2.106	17.980***
Total	5.281 ± 1.882	7.472 ± 1.480	5.539***	1417.430 ± 1.595	1342.990 ± 1.661	198.597***

**p < 0.05; ***p < 0.001; df = 74*

5.2.2 Perceptions and Cognitive Loads

Based on the questionnaires' responses from students in EG group, the results are presented in Table 4 on low- and high- achievements. For the perceptions towards TheLittleSatis application, the results ranged between high and very high on all dimensions, meaning that the students were satisfied with the game story in the application. However, it was found that students with high achievements rated significantly higher on content and presentation, which made them learned effectively than those who got low achievements.

Nevertheless, students with low results found the game generated mental loads significantly higher than those who had high achievement, implying that they confronted difficulty and challenges while learning, which could be the factor that affects the learning performance for them. While the high achievers put significantly less mental efforts to use the game, it means that they could use the app to learn comfortably as the game story was well organized.

Based on the experiment, TheLittleSatis could provide significant effectiveness on promoting the sustainability understanding compared to the traditional e-learning method. This result was supported by the benefits of game-based learning design that the missions could visualize the intangible

learning concept in the engaging way to learn, as in agreement with Gobel, Muller, Urban and Wiemeyer (2012) and Romero (2013). By playing on the mobile device, students could interact and perceive the learning concepts behind game story intuitively (Ziesemer, Müller, & Silveira, 2013). Moreover, the missions designed in each game could help students to practice in the engaging, meaningful environment, while the students with higher achievement could collect more game points and spent lesser time than those who got the lower achievement. Furthermore, the former better perceived the content presented in each game story than the latter with less difficulty and challenge to learn on the new platform. These results are in corresponding with several studies that the high achievers had the faster ability in adapting themselves to gain new knowledge on the new platform with less anxiety and concerns (Chen, Hwang, & Tsai, 2014). Consequently, the contribution of this study could provide a practical perspective on game story design in closing the learning gap with interactive, relevant game missions for a development of mobile game learning environment.

Table 4: Students' perceptions and cognitive loads on TheLittleSatis on low- and high- achievement.

Dimension	Rating (M ± SD) (Interpretation)		*t*
	Low (*n* = 42)	High (*n* = 34)	
Perceptions – ranging between 1 (lowest) and 5 (highest)			
Content	4.212 ± 1.508 (high)	4.882 ± 1.491 (very high)	1.935*
GUI/Multimedia	4.690 ± 2.364 (very high)	4.745 ± 1.022 (very high)	0.126
UX/Interaction	4.488 ± 1.233 (high)	4.541 ± 2.104 (very high)	0.136
Presentation	4.272 ± 0.877 (high)	4.852 ± 1.620 (very high)	1.989*
Cognitive loads – ranging between 1 (not at all to me) and 7 (very true to me)			
Mental loads	4.972 ± 1.787 (high)	4.135 ± 1.669 (middle)	2.090*
Mental efforts	4.295 ± 1.932 (middle)	3.057 ± 2.144 (low)	2.644***

**p < 0.05; ***p < 0.01; df = 74*

Finally, to make use of this game effectively, the authors would suggest following guidelines: 1) it is best to use on the bigger screen or tablets as some small objects in game might not be easy to interact with, 2) there should be a teacher to facilitate students while playing the game to provide more explanations and examples that are personalized to individual students, and 3) in some case with limited number of qualified devices, pair learning might be interesting alternative as they could discuss with the peer and exchange personal experience while learning. Additionally, the proposed game can be used in many schools with further investigations, e.g. gender difference, learning behavior, learning motivation, and its effect can be studied. With the limited time in developing this game version, several improvements can be made, e.g. personalized game missions to different groups of learners, a dashboard of learning reports for instruction adjustments, more games/missions to better engage and connect students in multi-languages. Moreover, data mining technique can be adopted for a better understanding of students' usage behaviors, while formative assessment analysis could be conducted.

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