

Save the Planets: A Multipurpose Serious Game to Raise Environmental Awareness and to Initiate Change

Extended Abstract[†]

D. S. Özgen

Department of Interior Architecture
and Environmental Design
Bilkent University
Ankara, Turkey
dilayozgen@bilkent.edu.tr

Y. Afacan

Department of Interior Architecture
and Environmental Design
Bilkent University
Ankara, Turkey
yasemine@bilkent.edu.tr

E. Surer

Department of Modeling and Simulation
Graduate School of Informatics
Middle East Technical University
Ankara, Turkey
elifs@metu.edu.tr

ABSTRACT

Serious games address not only entertainment purposes but also the transformations on the behaviors of their players. Serious games have recently been used in several domains, such as education, training, rehabilitation, and defense. The positive impacts of the serious games have been highly emphasized in the literature given their strong elements in motivation, a sense of progress, and a sense of purpose. Thus, this study aims to transfer these well-known strengths of serious games to environmental awareness. To do so, a life simulation-like serious game, Save the Planets, has been developed to nurture, care about, and learn from the Solar system. The game also lets the users create their own customized systems so that the aspirations and priorities of the players could be detected. To measure the immediate impact of the Save the Planets serious game, three different scales —Environmental Identity Scale, Pro Environmental Behavior Scale, and Environmental Action Scale— were applied in the pre-test and post-test evaluations of the 22 participants. The results show that the Save the Planets serious game significantly changes the pro-environmental awareness, and this serious game may be used to better inform and motivate the participants to take long-term actions.

CCS CONCEPTS

• **Human-centered computing** → **Human Computer Interaction (HCI)** → **HCI design and evaluation methods** → **User studies**

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KEYWORDS

Serious Games, Video Games, Environmental Identity Scale, Pro Environmental Behavior Scale, Environmental Action Scale.

1 INTRODUCTION

The serious game concept [1] was revealed to test, change, or determine human behaviors mainly for the education, training, defense, and rehabilitation [2]. Playing games has advantages more than just entertainment —i.e., it is one of the most pervasive, profitable, and influential forms of entertainment [3]. Nowadays, games are included in different research fields such as health [4], cognitive skills training [5], and games for learning [6]. The idea shares aspects with simulation generally, including flight simulation and medical simulation, but especially emphasizes the added value of fun and competition [7]. Serious games through the well-designed digital games have the main goal; shape human behavior, cognition, or attitude through educating users, motivating them, and encouraging participation [8]. It was also defined as “any form of interactive computer-based game software for one or multiple players to be used on any platform and that has been developed with the intention to be more than entertainment” [9].

When the current problems of the Earth are considered, an increase in industrial production, a grand amount of consumption and consumerism, paying no attention to nature and resources have been causing climate change and ecological disasters. The report of the United Nations (2019) [10] gives a clear warning about what will happen in the next decades if climate change is not taken into consideration seriously. The report shows that the globe is getting warmer than expected —1.5 °C degrees more. Given the severity and urgency of the subject, this study focuses on implementing a serious game to raise awareness about the environmental challenges and to initiate change in the long-term.

Many psychologists and environmental designers [11-12] have already studied environmental approaches before. In recent studies, it was indicated that serious games, which are aiming to help environmental issues, have positive effects on players for cognitive outcomes, user experiences, knowledge, and learning [13]. With

the light of these findings, the research question of this study revolves around the question: “How do serious games promote environmental awareness?”. In order to answer this question, a thorough literature survey has been conducted, followed by the proposal of a serious game-based methodology.

Previous studies demonstrate that people who have pro-environmentally conforming actions also aim at protecting their physical and social environments [14]. Therefore, it can be said that having pro-environmental and pro-social behavior within the ecological concept are sustainable behaviors. With the light of the abovementioned information, behavioral changes are needed to protect the ecological environment, and therefore, environmental behaviors should be encouraged. There are different methods to support behavioral alteration, and one of them is using serious games. In order to evaluate the impact of serious games in encouraging pro-environmental behaviors, sustainable behavior measures should be addressed. To better understand whether a serious game can alter or develop a certain human behavior in terms of environmental awareness, first, how much players feel the connection with the natural world should be understood. To do so, in this study, Environmental Identity Scale (EIS) —a 12-item scale— was adapted from Clayton [15]. Understanding the participant’s connection with nature is crucial given that previous studies [15] show that supporting universal values, environmental behaviors, and environmental decision-making is related to the environmental identity.

Another indicator of environmental awareness is defined as pro-environmental behavior —individual behaviors contributing to environmental sustainability by limiting energy consumption, avoiding waste, recycling, and environmental activism [16]. Thus, one key question is how to encourage pro-environmental behaviors among individuals, including actions that are intended to minimize environmental harm or improve environmental conditions. By far, the most common psychological approach to promote pro-environmental behavior focuses on changing the person. In the public arena, such approaches can be listed as campaigns, raising awareness, outreach, or education. The fundamental premise behind this approach is that individuals fail to engage in pro-environmental behavior (PEB) because they lack sufficient knowledge and motivation. They just do not care, they are not aware of the harmful consequences of their actions, and they do not know what to do, or are not sufficiently motivated to take action [17]. Serious gaming can help the participants take action and, therefore, to promote PEB. There are many PEB scales in the literature; in this study, we used Markle [16]’s new measure for PEB through analyzing and testing existing measures. It consists of 19 items and four dimensions; conservation, environmental citizenship, food, and transportation, and we adapted this scale within the scope of this study.

Moreover, while promoting environmental awareness, studies focus on changing behaviors. However, there is a lack of understanding to define terms as environmental behavior, environmental action, and environmental activism [18]. Although all terms are under the umbrella term of pro-environmental behavior, it is important to define “environmental actions are

intentional and conscious civic behaviors that are focused on systemic causes of environmental problems and the promotion of environmental sustainability through collective efforts” [12], and to measure those behaviors, Environmental Action Scale (EAS) [12] was developed. We also adapt this scale for this study to show whether serious game change players’ actions. This scale includes 18-items, and we used 11 items that are related to the scope of this study. The indicator of sustainable behavior is saving energy, caring for others, recycling, minimizing consumption, etc. Serious games enable users to gain knowledge about the energy-saving strategies available to them and then explore alternative means of achieving energy saving. There is plenty amount of research about serious game testing energy-saving strategies using qualitative, quantitative, or mixed methods. Some of them indicate the behavioral change in both gameplay and in real life. For instance, EnerCities [19] and EnergyLife [20] games explored behavioral changes during gameplay. EnerCities online game study discovered a significant increase in attitudes towards saving energy and performing specific energy-related household behaviors among 653 participants using quantitative and quasi-experimental study design. Besides, EnergyLife mobile application raised awareness among 24 participants about energy consumption. Energy Battle [21], Power Explorer [22], and Power Agent [23] are the serious games that change people positively in real life. The abovementioned studies mostly focus on energy-saving strategies, and they support behavior change in a sustainable way.

In this study, we extend the use of serious games by developing a serious game prototype that measures the immediate effects of nurturing the planets on environmental awareness and analyzes the initial evaluation outcomes to design a long-term study aiming to lead these immediate effects to lifelong pro-environment actions.

2 MATERIALS AND METHODS

2.1 Serious Game

“People have forgotten this truth,” the fox said. “But you must not forget it. You become responsible forever for what you have tamed. You are responsible for your rose.”

— Antoine de Saint-Exupéry, *The Little Prince* [24].

In this study, we developed the Save the Planets serious game (Figure 1), which aims to remind the truth abovementioned by Little Prince —i.e., to make its players feel responsible for their planets and actions. This serious game was built in Unity game engine as a 2D PC and/or mobile game based on life simulation games and artificial/virtual pet video games and toy genres like Tamagotchi [25]. In the game, the Earth is born as a mixture of dust and cloud, and it needs to be cared for and raised by someone in order to grow. To raise it, there are buttons; human beings, Sun, Moon, resources, and pop-questions. During the gameplay, the player should click on these buttons and use left and right direction keys to collect items floating from above. There are certain types of human beings and resources, which are harmful and beneficial for the Earth. Players should collect environmentally aware and respectful human beings and escape from harmful ones. Also,

players should collect renewable resources and escape from nonrenewable resources. During the game, players can also answer questions on the factual information on planets so that they can gain points and lead to the Earth's and planets' growth. Also, when the players reach to higher levels, they can raise multiple planets at the same time.



Figure 1: The opening screen of the Save the Planets serious game.

Game Idea: Rowert Swan [26] said, “The greatest threat to our planet is the belief that someone else will save it.” To overcome this lack of responsibility, we decided to design a serious game in the environmental awareness context, which helps adults and children think about caring for their environment and taking responsibility for Earth and other planets (Figure 2).

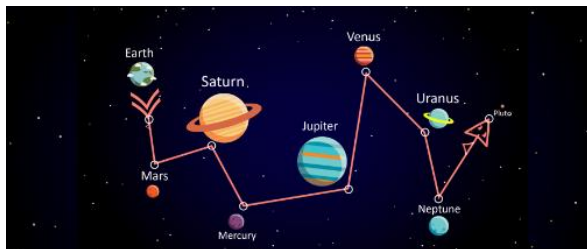


Figure 2: The visuals of the planets in the Solar system.

Game Summary: The story of the game starts from the very beginning, and the players are welcomed with this introductory message:

“Big bang! The Earth is a dust cloud. It needs to be cared by someone. Now you are responsible for the Earth. You have to feed, provide comfort, and make it pleasant and happy. As similar to Earth, each planet has different components and needs. You can feed the Earth with human beings. If you feed it too much with human beings, the Earth will be sick because humans reduce the resources of the world. In order to heal it, send wind turbines, wind, watermill, and rain that are renewable resources. If you want to make the world pleasant, use Sun and Moon when necessary. While you are caring for your planets, they will grow step by step. When they reach a certain size, another planet will be unlocked.”

Characters: There would be various characters as a planet, but the game starts with the Solar System planets, which are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.

Each planet has a different personality. For instance, the Earth is nurturing and curious, and it keeps humans hospitably. Its close friends are Sun and Moon. When it receives human beings, it feels fulfilled and not hungry anymore. It plays with the Sun and Moon to become happy. It likes renewable resources to be healthy because humans sometimes destroy and make the Earth sick. Mars is lunatic and crazy. It is like the youngest child of the house. That is why it likes astronauts a lot so that it can scare them with meteor streams. Its close friends are the Sun and its own satellites. Saturn is calm and introverted. It keeps aliens with it and loves heat and gas, but aliens are affected by the heat and gas. Therefore, it uses them carefully.

Storyboard: There is a general map in the game and the player starts with the Earth—stage one. The player uses drag and drop features to raise the planets. For instance, there are Sun, Moon, and human being buttons at the bottom of the page, so the player can drag the human beings and move them into the Earth. There are four stages for each planet in order for the player to complete the game successfully. Between the stages, there are several tasks to be accomplished, and the number of the tasks increases as the stages do level up. In each stage, the planet's looks change (Figure 3).



Figure 3: The modifications on the Earth each time a new stage starts in the game.

After the player finishes the Solar System map (Figure 4), the player can create their own planet system by customizing and personalizing the already-available planets, which will adapt to live on the player's own customized system.



Figure 4: The “Hunger”, “Happiness” and “Health” of the Earth given the actions performed by the player using the buttons lined horizontally at the bottom of the screen.

Game Development Tools: The Save the Planets game (Figure 5) was built on Unity game engine while the models and the

graphics of the game were designed using Vector graphics software Adobe Illustrator, Adobe Photoshop, Blender, and Autodesk 3ds Max.



Figure 5: The mobile version of the “Save the Planets” serious game.

2.2 Participants

Participants were chosen from Bilkent University graduate students from Interior Architecture and Environmental Design Department and Middle East Technical University graduate students from the Multimedia Informatics program. Eight male and 14 female participants attended this study online, and their age range is between 20 to 30 years old. Since the game playing and testing protocol involved no invasive procedures or discomfort to the participants, ethical approval was granted by the Bilkent University internal ethical review board in March 2020.

2.3 Instruments

In order to measure the impact of the Save the Planets serious game, we used two instruments —pre-test and post-test evaluation. These tests include items from the abovementioned Environmental Identity Scale (EIS) [15], Pro-environmental Behavior Scale (PEBS) [16], and Environmental Action Scale (EAS) [12]. The pre-test aims to understand the players’ attitudes and awareness they already have, and the post-test aims to understand whether the game leads to any change in terms of players’ attitudes and awareness of the environment or their behavior. After we collected data from the participants, statistical data analysis was performed in IBM Corporation’s SPSS Statistics software.

2.4 Data Acquisition

The data acquisition process started during the COVID-19 lockdown, and therefore, the participants were informed through the e-mail group. The compressed file that includes a pre-test, a post-test, and the game, was sent via e-mail. First, the participants filled the pre-test that includes EIS, PEBS and EAS items. After they filled the pre-test, they played the Save the Planets game, and when they finished their gameplay, they took a screenshot of the game, so that the authors could keep the scores of the game and made sure that the game was completed. Finally, the participants

filled the post-test evaluation, and they sent their test results and screenshot of the game via e-mail.

3 RESULTS AND DISCUSSION

In this study, we implemented a new serious game to analyze its impact on increasing environmental awareness. Therefore, to measure its impact, we conducted two tests; pre-test and post-test, which could be the indicator of this alteration. As a result of the non-parametric test, A Wilcoxon signed-rank test showed that our serious game Save the Planets did elicit a statistically significant change in pro-environmental behaviors and environmental actions when the significance level is 0.05. Environmental actions are the most differentiated part of the test in a positive way. 20 participants changed their attitude positively after playing the game and only one participant changed their answer negatively and one kept the answers the same as before the gameplay. In addition to that, for the Question 22 ($p=0.025$) and Question 23 ($p=0.021$), there were significant differences. In the post-test, it is seen that after the gameplay, the participants were willing to become a member of conservation, or wildlife protection groups or donate to them.

Also, the mean and standard deviation values of each test in pre- and post-condition are reported (Table 1). The results showed that, in each of the conducted tests, mean values have increased —a trend demonstrating the increase in the responses targeting the pro-environmental aspects.

Table 1: Descriptive Statistics — Pre-Test and Post-Test results of the Environmental Identity Scale (EIS), Pro-environmental Behavior Scale (PEBS), and Environmental Action Scale (EAS).

Pre-Test	Mean	Standard Deviation
EIS	5,33	1.04
PEBS	3.72	0.54
EAS	1.34	0.64
Post-Test	Mean	Standard Deviation
EIS	5.50	0.92
PEBS	4.18	0.44
EAS	2.31	0.90

This study focuses on new ways of triggering a behavioral change in players with the aim of enhancing environmental awareness. Especially, this study presents a concept of a serious game that initiates behavioral shifts in players after gameplay and creating more pro-environmental attitudes. Therefore, it is important to understand the baseline —the existing behaviors of the participants to regulate how they already do things.

Personal characteristics of sustainable behaviors were analyzed in [27], and they indicated that the appreciations of beauty, creativity, and perspective are the most strongly associated strengths with sustainable behaviors. These characteristics (appreciation of beauty, creativity, and perspective) are also traits of a designer, so there may be an association between having environmental awareness and being a designer. To measure this

association, participants from different work experiences will be involved in future study.

The variety of the characteristics of the planets has been a positive aspect of the game, which was mentioned by our participants. Giving characteristics to the planets eased the connection between the player and the object of care. This perspective motivated the user to timely check the necessities of each planet by planning in advance due to the characteristics of the planet at that stage.

The visual and animated changes in the different stages of the planets were also important elements underlining the progress of the users and experiencing those changes, and seeing the impact of their actions motivated the participants.

The main limitation of the study was trying to perform the data acquisition procedure during the COVID-19 lockdown that caused the authors to limit the number of participants to 22. In future work, the number of participants will be increased. Interestingly, the participants reported that participating in a study on environmental awareness during lockdown helped them to cope with the feelings of helplessness.

Evaluating behavioral change is a wholesome approach in which the behaviors of the participants should be observed under different targeted tasks and for a longer period of time. This study demonstrates that having a serious game to nurture the planets and to take care of the necessities of them significantly increases environmental awareness and motivates the user for a change in their behavior. We will conduct a long-term study to monitor the impact of this awareness in different environmental tasks by adding new levels to the game and by also analyzing the customized solar system of the users to learn what their necessities, aims, and priorities are. Such a customized approach will enable us to pursue a long-term behavioral study taking into the participants' personal motivations into account.

4 CONCLUSION

In summary, this study proposes a new serious game, Save the Planets, which aims to increase the environmental awareness of their players and inform them of the current environmental challenges. The game enables the players to nurture planets that have different characters and to create their own solar system. By nurturing each planet in pre-determined time intervals, a sense of connection and responsibility grows between the user and the planet. This sense of connection and responsibility causes immediate positive pro-environmental results, which were measured using three different scales —Environmental Identity Scale, Pro Environmental Behavior Scale, and Environmental Action Scale. The results showed that Save the Planets serious game positively affects its players on pro-environmental awareness, which can also motivate them to follow up actions that handle the necessities of their environments and the challenges learned from the game.

A APPENDIX

A.2.1 Environmental Identity Scale

Environmental Identity Scale Adapted from Clayton, 2003

The originators of the below questionnaire were contacted, and the permission to use the questionnaire has been obtained from Susan Clayton

Gender:	Female	Male	Not prefer to say	(use x for one)
Living location:	Campus	Urban	Rural	(use x for one)
Please indicate the extent to which each of the following statements describes you by using the appropriate number from the scale below				
1	2	3	4	5
6	7			
Not at all true of me		Neither true nor untrue		Completely true of me
1. I spend a lot of time in natural settings (forest, mountains, lakes, seaside)				
2. Engaging in environmental behaviors is important to me				
3. I think of myself as a part of nature, not separate from it				
4. If I had enough time I would work for environmental causes				
5. When I am upset or stressed I can feel better by spending some time in nature				
6. Living near nature is important to me; I would not want to live in a city all the time				
7. I like to garden				
8. Being a part of ecosystem is an important part of who I am				
9. Behaving responsibly towards the earth -living a sustainable lifestyle- is part of my moral code				
10. Learning about the natural world should be an important part of every child's upbringing				
11. I would rather live in a small house with a nature landscape view than a bigger house with a view of other buildings				
12. I really enjoy camping or/and hiking outdoors				

A.2.2 Pro Environmental Behavior Scale

Pro Environmental Behavior Scale adapted from Markle, 2013

The originators of the below questionnaire were contacted, and the permission to use the questionnaire has been obtained from Gail Markle

Please indicate the extent to which each of the following statements describes you by using the appropriate number from the scale below				
1	2	3	4	5
Never	Rarely	Sometimes	Usually	Always
1. How often do you turn off the lights when leaving a room?				
2. How often do you cut down on heating or air conditioning to limit energy use?				
3. How often do you turn off the TV when leaving a room?				
4. How often do you limit your time in the shower in order to conserve water?				
5. How often do you wait until you have a full load to use the washing machine or dishwasher?				
6. How frequently do you watch television programs, movies, or internet videos about environmental issues?				
7. How often do you talk to others about their environmental behavior?				
Please indicate the extent to which each of the following statements describes you by using the appropriate number from the scale below				
	1		3	5
	hot		warm	cold
8. At which temperature do you wash most of your clothes?				
Please indicate the extent to which each of the following statements describes you by using the appropriate answer from the below				

Yes	No	
9. Are you currently a member of any environmental, conservation, or wildlife protection group?		
10. During the past year have you contributed money to an environmental, conservation, or wildlife protection group?		
11. During the past year have you increased the amount of organically grown fruits and vegetables you consume?		
please indicate the extent to which each of the following statements describes you by using the appropriate number from the scale below		
1	3	5
Never	Occasionally	Frequently
12. During the past year how often do you have car pooled?		
13. During the past year how often have you used public transportation?		
14. During the past year how often have you walked or cycled instead of driving?		

A.2.3 Environmental Action Scale

Environmental Action Scale adopted from Alisat and Riemer, 2015
The originators of the below questionnaire were contacted, and the permission to use the questionnaire has been obtained from Susan Alisat

Please indicate the extend to in the last six months, how often, if at all, have you engaged in the following environmental activities and actions by using the appropriate number from the scale below				
0	1	2	3	4
Never		Sometimes		Frequently
1. Educated myself about environmental issues (e.g., through media, television, internet, blogs, etc.)				
2. Participated in an educational event (e.g., workshop) related to environmental issues				
3. Talked with others about environmental issues (e.g., friends, parents, etc.)				
4. Used online tools (e.g., Instagram, Youtube, Twitter, etc.) to raise awareness about environmental issues				
5. Personally contact with a politician/government official about an environmental issue				
6. Became involved with an environmental group or political party (e.g., volunteer, summer job, etc.)				
7. Financially supported an environmental cause				
8. Took part in a protest/rally about an environmental issue				
9. Consciously made time to be able to work on environmental issues (e.g., choosing environmental activities over other leisure activities)				
10. Participated in nature conservation efforts (e.g., planting trees)				
11. Spent time working with a group/organization that deals with the connection of the environment to other societal issues such as justice or poverty				

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