Trash Attack: A 2D Action Puzzle Video Game to Promote Environmental Awareness and Waste Segregation Behavior

Ma. Corazon G. Fernando [1,2], Manuel B. Garcia [1,3], Maria Vicky S. Solomo [1,4], Ace C. Lagman [1,5]
[1] Department of Information Technology, FEU Institute of Technology, Manila, Philippines
[2] mgfernando@feutech.edu.ph, [3] mbgarcia@feutech.edu.ph, [4] mssolomo@feutech.edu.ph, [5] aclagman@feutech.edu.ph

***Abstract*—In the landscape of contemporary education, raising environmental awareness is considered a vital goal that lies in the interdependence between humankind and environment not only to encourage conservation of irreplaceable natural resources but also to foster a sense of connection to the natural world. As part of the contribution of the proponents to create a medium that can promote environmental education, an action puzzle video game called Trash Attack was developed. Trash Attack is a 2D-based video game with a storyline that revolves around a girl named Julie who is tasked by Heidegger Industries to clean up a community full of waste using her special gun that can teleport trash to waste processing facilities to be recycled or disposed of properly. To help combat the increasing waste disposal and spread environmental awareness, the game mechanics was designed to make players familiar with the idea of waste segregation. Thirty-six respondents assessed the game and the game evaluation has proven the following points: (1) that the game promoted awareness to the environment while being fun and engaging, (2) that the game has performed efficiently while running, showing little or no frame rate issues and have caused minimal inconvenience to the players, and (3) that the game has been successfully ported to mobile devices allowing everyone to play and be educated.**

Keywords - Environmental Awareness, 2D Video Game, Waste Segregation, Action Puzzle Game

I. INTRODUCTION

In the Philippines, waste disposal has been a major issue where the health of the citizens is becoming vulnerable to the serious threat it transports [1]. The increasing size of landfills and garbage getting thrown in waterways and rivers are clear signs that people are not learning to properly dispose of trash [2]. Nevertheless, the situation of poor waste management is the responsibility of both the authorities and the populations that nonetheless cause the spread of uncontrolled solid waste when it is nonexistent. The abandonment of waste will most likely expose the population to health hazards posed by the waste [3]. In the field of environmental education, it has been studied that giving social duty awareness along with waste management awareness to people may improve the practice of waste management. This can be provided by the education department by developing educational programs or materials dedicated to the environment which can be distributed to the population. A chain of studies [2, 4, 5] contends that students have low awareness in the solid waste segregation regardless whether the school campuses are equipped with the standard color coding trash bins (yellow for non-biodegradable, green for biodegradable, black for recyclables) since students were observed to ignore the proper waste disposal and continue to throw trash on the wrong bins. Another study has found out that households with low educational attainment tend to burn plastic that contribute more to the harm of the environment. The study, thus, has recommended that organizations that are promoting environmentalism must come up with programs that can promote awareness in a participatory manner [6].

To contribute in promoting environmental awareness, an action puzzle video game called "Trash Attack" was created. As such, this study aimed to develop an action puzzle game that has an environmental education theme using Unity with a development span of four months. Specifically, this study aimed to achieve the following: (1) create an action puzzle game that promotes environmental awareness through waste segregation, (2) provide a fun and engaging way to promote environmental awareness; and (3) design a gameplay that is balanced and user-friendly on the players. Trash Attack, with spreading environmental awareness in mind, is meant to help combat the increasing waste disposal problem in the country. This environmental video game shadowed the action puzzle genre since a puzzle game has a massive acceptance in the market and has been one of the longest existing genres of the video game industry dating as far back as 1970s. The video game mechanics were simple to mimic a casual game, which is one of the fastest growing genres of the gaming industry today. This game development was also aimed to utilize the proponents' skills and knowledge in game while learning to work together as a team. The end goal is to release the video game where players could have enlightened and be aware of the environment through the practice of waste segregation. The game mechanics was focused on revolving around the theme of waste segregation for players to become familiar with the idea since waste segregation is one of the easiest and the most effective way of combating the waste problem in the Philippines. Video games have been an effective tool for educating people [7] since they are fun and stimulating and requires the audience's complete attention [8].

Fig. 1. Trash Attack Game Application Splash Screen Design

II. TRASH ATTACK – A 2D PUZZLE VIDEO GAME

Trash Attack is an action puzzle game where players can take control of Julie, a potent environmentalist who has only one mission in life: to promote environmental awareness by cleaning the environment using her special gun. The game features an endless game mode in which the player must try to survive the increasingly difficult waves of trashes. Trash Attack has a game loop architecture designed to consistently throw waste and trash, which Julie needs to shoot using the appropriate colored gun. Biodegradable wastes, e.g., human and animal waste, food scraps, manufactured products based on natural materials, etc. should be shot using the green gun. On the other hand, non-biodegradable wastes such as plastic products, metals, constructions wastes, etc. should be shot using yellow gun. Lastly, recyclable wastes such as plastic, textiles, tires, cardboards, electronics, etc. should be shot using the blue gun. The game storyline utilized voice acting dialogues in order to make sure that the players can interact with the game naturally. Game assets such as waste images, characters, and background were designed using comic style art as the inspiration. The sound effects were obtained via a group of royalty free music websites. The video game was developed by the proponents throughout a span of three to four months by using Unity Engine, Photoshop, Illustrator, Autodesk Maya, and other multimedia editing applications. The game project was meant for educational reference only, therefore, the final output will not be used for profit.

Fig. 2. Trash Attack Waste Segregation Screen

Fig. 3. Trash Attack Storyline Screen

III. Research Methodology

To develop the action puzzle video game in an interactive manner, an agile methodology was employed to manage the game development project. The Scrum framework was used, thereby dividing the tasks into parts called "sprints" that last by a week as monitored by the project manager. Progress of the project is recorded when a team member finishes a task according to the timeline. The tasks that are not completed were re-evaluated whether it should be continued, excluded or substituted by a new task, and if it will be assigned to a new member. Scrum gives the developers an opportunity to create certain goals that promotes distributed work for all the members of the game project. The game development was composed of four stages in which the team performed a series of tasks that build up into milestones of every stage. The first stage was prototyping where the team produced a viable game prototype with all the key gameplay elements and assets needed to make the game playable. The prototype was ensured to satisfy the project's objectives. The second development stage was the Alpha stage, where a continuous testing of output was achieved. The evaluation of every test could alter the task in terms of specifications or change the task entirely which can be done throughout the duration of the sprint. More assets were developed during this stage and there were revisions as envisioned by the game designer that must be done in preparation for the next sprint. Next was the Beta stage, where the beta version game build as a result of the alpha stage was tested by users outside the development team to provide user-feedback and information to further improve the game, as well as insights to any problem the development team had overlooked during the alpha stage. Finally, the last stage was where game developers applied final revisions for the assets and changes needed to be done to solve major problems uncovered during the beta testing in order to prepare the game for final release. As an additional layer of evaluation, the proponents played the game one last time and reviewed the final game architecture.

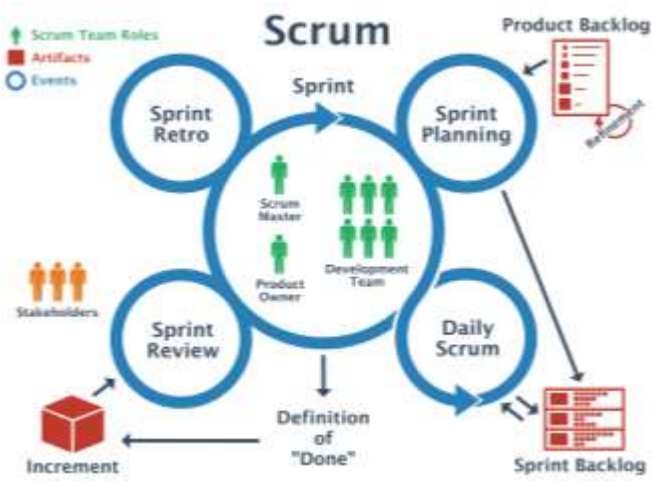

Fig. 4. Scrum Project Methodology

To evaluate the game, an online survey questionnaire via a private web server was disseminated to participants. Using MEEGA+ [9], a game evaluation tool for measuring player experience and usability of educational games, the questions from the questionnaire were created. The MEEGA+ model is decomposed into two factors as seen on Table 1 below.

TABLE I. DIMENSIONS OF MEEGA+

Factor	Dimension	Definition
Usability	Aesthetics	Game interface enables pleasing and satisfying interaction
	Learnability	Game achieved specified goals of learning to use the game.
	Operability	Game has attributes that are easy to control.
	Accessibility	Game can be used by people with visual impairment.
Player Experience	User error protection	Game protects users with against making errors.
	Focused Attention	Game motivates users to focus and concentrate.
	Fun	Game lets students enjoy and relax while playing.
	Challenge	Game is challenging with respect to users' competency.
	Social Interaction	Game promotes a feeling of shared environment.
	Confidence	Game lets students progress through their effort and ability.
	Relevance	Game has educational content is consistent with the goals.
	Satisfaction	Game projects users' dedicated effort to result in learning.
	Perceived Learning	Game is evaluated on the overall impact to users.

IV. Results and Dicussions

For the game ratings, this study made use of the five-point Likert scale in which questions were answered in a set of ratings, in this case, a five-point scale. The table 2 below summarizes the rating, the mean range, and corresponding verbal interpretation. Data has been tabulated a weighted to get an overall evaluation of each criteria of the game. Using a free online survey hosted on a private server, the survey questionnaire was distributed along with a download link of the game. Throughout the next seven days, 36 respondents have downloaded the game in both PC and mobile version, and answered the survey based on MEEGA+.

TABLE II. LIKERT SCALE TABLE

Rating	Mean Range	Interpretation
5	4.50-5.00	Excellent
4	3.50-4.49	Good
3	2.50-3.49	Fair
2	1.50-2.49	Poor
1	1.00-1.49	Bad

An additional question before the game evaluation was also asked to the players: "Are you currently studying or graduated in the field of Information Technology?" As per the next part of the survey questions, each criterion has a corresponding number of questions to be answered after the

game play test which aimed to describe the experience and perception of the players regarding the game, and possibly its impact after playing it. With this criteria evaluation, the respondents, and possibly those who are truly interested to develop similar game concept and public service mission, will have the basic understanding and comprehension on how to proceed in designing and developing environmental games in the perspective of the target game players.

TABLE 3. MEEGA+ SURVEY RESULTS

Factor	Dimension	Rating [mean ± SD]
Usability	Aesthetics	4.2 ± 0.5
	Learnability	4.8 ± 0.2
	Operability	4.1 ± 0.9
	Accessibility	3.2 ± 1.1
Player Experience	User error protection	4.3 ± 0.3
	Focused Attention	4.3 ± 0.3
	Fun	4.1 ± 0.3
	Challenge	3.5 ± 0.6
	Social Interaction	3.4 ± 0.7
	Confidence	4.4 ± 0.3
	Relevance	4.9 ± 0.1
	Satisfaction	4.0 ± 0.4
	Perceived Learning	4.4 ± 0.2

V. CONCLUSION

This chapter discussed the summary of the findings of the game evaluation using MEEGA+ during the creation of Trash Attack. Based on the total ratings, the video game has performed well in all dimensions of the survey instrument. Most importantly, the results have proven that: (1) the game promoted awareness to the environment while being fun and engaging, (2) it performed efficiently while during runtime, showing little or no frame rate issues and inconvenience to players and (3) Trash Attack has been successfully ported to mobile devices. Trash Attack, based on the given results of the game evaluation process, has fulfilled the objectives of the study. It has provided an environmental education and has provided a sense of awareness to the environment and proper waste segregation behavior to the players. It was a fun and engaging game. As an addition, the proponents have made the game playable in mobile devices since it is the suitable platform for delivering game-based learning [10].

Future respondents are advised to be very careful in setting their objectives because it has a major influence in the overall development time and will limit the gameplay. If possible, future proponents can focus on the following: (1) develop varied gameplay modes with integration of suitable game algorithm [11], (2) create gameplay mechanics that disperse an appeal to hardcore gamers, (3) focus on games that could contribute to the society [12], and (4) research more about environmental factors to determine as to why waste disposal continues to be a problem in the Philippines.

FUNDING

This research was partially supported by FEU Institute of Technology in terms of presentation and publication fee.

REFERENCES

[1] V. R. K. R. Galarpe, "Review on the Impacts of Waste Disposal Sites in the Philippines," *Science International,* vol. 29, pp. 379-385, 2017.

[2] D. V. Madrigal and E. G. Oracion, "Solid Waste Management Awareness, Attitude, and Practices in a Philippine Catholic Higher Education Institution," *Recoletos Multidisciplinary Research Journal,* vol. 5, 2018.

[3] P. Kafando, B. G. r. Segda, J. F. l. Nzihou, and J. Koulidiati, "Environmental Impacts of Waste Management Deficiencies and Health Issues: A Case Study in the City of Kaya, Burkina Faso," *Journal of Environmental Protection,* vol. Vol.04No.10, p. 8, 2013.

[4] C. Licy, V. Raghavan, and S. Kamath, "Awareness, Attitude and Practice of School Students towards Household Waste Management," *Journal of Environmental Protection,* vol. 2, 2013.

[5] A. Ifegbesan, B. Ogunyemi, and I. Rampedi, "Students' attitudes to solid waste management in a Nigerian university," *International Journal of Sustainability in Higher Education,* vol. 18, 2017.

[6] C. I. Ultra and A. A. Ultra, "Solid Waste Management Practices of Households in the University of Eastern Philippines " *Journal of Energy Technologies and Policy,* vol. 3, pp. 32-34, 2013.

[7] M. B. Garcia, "Kinder Learns: An Educational Visual Novel Game as Knowledge Enhancement Tool for Early Childhood Education," *The International Journal of Technologies in Learning,* 2019.

[8] M. Griffiths, "The educational benefits of videogames," *Education and Health,* vol. 20, pp. 47-51, 2002.

[9] G. Petri, C. G. von Wangenheim, and A. F. Borgatto, "MEEGA+: A Method for the Evaluation of Educational Games for Computing Education," *INCoD – Brazilian Institute for Digital Convergence,* pp. 1-47, 2018.

[10] M. B. Garcia and J. B. Mangaba, "Delivering Effective Digital Game-Based Learning: A Comparative Study Between Computer and Mobile as the Learning Framework for Preschoolers," in *1st International Conference on Information Technology, Education, Engineering, and Management Sciences*, 2017.

[11] T. F. Revano, M. B. Garcia, B. G. M. Habal, J. O. Contreras, and J. B. R. Enriquez, "Logical Guessing Riddle Mobile Gaming Application Utilizing Fisher Yates Algorithm," in *2018 IEEE 10th International Conference on Humanoid, Nanotechnology, Information Technology,Communication and Control, Environment and Management (HNICEM)*, Baguio City, Philippines, 2018.

[12] M. B. Garcia, "Speech Therapy Game Application for Aphasia Patient Neurorehabilitation – A Pilot Study of an mHealth App," *International Journal of Simulation Systems, Science & Technology,* vol. 20, pp. 5.1-5.9, 2019.