FORMING A HEALTHIER AND SAFER ENVIRONMENT THROUGH GAME-BASED LEARNING

A THESIS BY

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FUN WAYS TO THRIVE

APPROVAL SHEET

This thesis proposal entitled *FORMING A HEALTHIER AND SAFER ENVIRONMENT THROUGH GAME-BASED LEARNING*, prepared and submitted by *ADRIAN MIGUEL C BANTILING & PRINCESS LARAZEA G RONDA*, in fulfillment of the requirements for the degree **BSCS ST** is hereby accepted.

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ABSTRACT

Proper waste management and conserving natural resources have been addressed numerous times before with each iteration utilizing a different method in its take on these problems. Ranging from small communal activities to international movements, each of these methods has proven that knowledge and awareness can improve a person's outlook on the aforementioned issues. E-learning, specifically game-based learning, has also been used as an effective tool in addressing these issues, with each having varying game mechanics and degrees of success. In this study, we compared various video games with themes of environmental conservation as well as waste management to replicate and enhance the features and mechanics that made these games successful. This study exhibits the effectiveness of game-based learning in spreading knowledge and awareness on proper waste management and natural resources conservation by conducting tests, before and after playing the game with younger siblings while utilizing time in times of crisis.

Keywords: environmental awareness; game-based learning; e-learning effectiveness

I   INTRODUCTION

1.1   BACKGROUND OF THE STUDY

As our population increases day by day, the knowledge on how to keep our planet a safe and healthy haven for us becomes more relevant — unnecessary consumption is more prominent which leads to the growth of the amount of waste made by people who do not know how to properly manage them. Any immediate solution to helping the environment becomes significant. People may not be able to stop waste production and excessive consumption of resources, as there are no 'silver bullets' for those problems, but spreading knowledge and awareness on these issues can be a big step for a significant change. As Manila Times' opinion on the subject matter; they pointed out that citizens should actively participate and learn from the best and most effective practices. Recent efforts, namely, the 4ocean movement and the Breast's Team Trees have shown that people are indeed willing to help with the cause, we only need to reach out to them.

Human populations, like those of other organisms, expand if there are adequate resources and no other controls. For humans, technology has greatly facilitated the population growth and greatly increased our environmental impact,[1] both positively and negatively. Improper methods of waste management had a mass contribution in increasing environmental issues. Knowledge and awareness of proper waste management and conserving natural resources must then be cultivated in the coming years to ensure the well-being of the environment.

Increasing an individual's waste management knowledge is through waste management counseling. However, waste sorting and recycling messages are often challenged because they force an individual to change their behaviors.[2].

1.2   OBJECTIVES OF THE STUDY

The goal is to enhance the knowledge of our younger siblings and younger relatives; with the age range 7-10 about conserving natural resources through game-based learning.

To achieve the general objective, it's essential to 1) develop the game in Unity Game Engine and design the animations; using Aseprite. 2) Developers can then be able to test and analyze the developed desktop game for its performance and efficiency a week of the end of May 2020; and 3) determine the effectiveness of learning through game for kids; ages 7-10, through pretest and posttest.

1.3   SIGNIFICANCE OF THE STUDY

The game revolves around knowledge on conserving natural resources, thus – potential awareness about this topic can be gained. Yuen, Hung, Hwang, & Lin in 2011 used game-based learning in a nutrition course and discovered that this approach was more effective in enhancing the learning effectiveness and attitudes of students than traditional PPT teaching and even influenced their dietary habits[4].

Fun Ways to Thrive can be beneficial after it is played when a player is placed in the same real-world situation after playing and can see the changes and impact of their action's over-time.

With global problems regarding climate change and solid waste management. It is essential, then, as practitioners of this field of study that the researchers contribute to the cause knowing how advantageous technology is; Making a game that spreads knowledge and awareness can become an important milestone towards saving the environment.

1.4   SCOPE AND LIMITATIONS

The game was solely developed in Unity Game Engine. The researchers chose Unity due to its accessibility and its interactive interface. The game is mainly a Windows Desktop Game with 6 mini-games (refer in appendix B for the list of games) an Android version would have been released if there wasn't a pandemic but because of it; time constraint couldn't meet. The game is intended for children ages 7-10 as deemed so because kids in those ages are mindful enough to understand complex subjects, such as those regarding the environment while retaining their child-like innocence and playfulness.

The researchers aimed to build a game that can 1) provide knowledge about saving resources and conserving natural resources 2) Implement the series of mini-games and integrate it into one seamless flow. At the given time and resources, 3) 6 mini-games must then be ready for testing. The mini-games are limited to 6.

Due to the outbreak, the researchers can only do alpha testing and have 4 kids to take the test; specifically, younger siblings and other younger relatives to monitor and have scheduled time to play the game, survey them accordingly to see if the game had improved their knowledge and awareness on the aforementioned issues.

2 THEORETICAL FRAMEWORK

2.1 REVIEW OF RELATED LITERATURE

Given the current state of the solid waste management system in the Philippines, it indicates that the government cannot solve the enormous waste problems without the contribution of other stakeholders and assessment of many other important matters aside from the technical or technological perspective (i.e. political, social and economic perspective). Atienza in 2011 addresses that the sustainable solid waste management system and recycling industry of the country can be attained by having good environmental governance through collaboration with other stakeholders, effective public information dissemination through campaigns and promotions, and shared ideas on innovative and appropriate technology.[5] Technology perhaps could lead to big changes and improvement as stated only if people have adequate solutions without being too grand and are actually solving the problem in their own little way.

A study observed that some learners exhibit a cognitive preference for certain media. For example, the younger generation prefers portability and is frustrated by the technology that ties them to a specific location. Studies also show that they do not read as much as previous generations but prefer video, audio, and interactive media. Some have argued that the younger generation has a shorter attention span and requires learning in 'small size chunks'. [3] A learning-based system that combines technology with teaching is said to communicate more efficiently and are very effective teaching devices. [4] They offer us a rich field for a risk-free active exploration of serious intellectual and social problems. Interactive games over the years have commonly proved to help us engaged in the real learning process. It was said to motivate students in a fun way and offer interactive competitive learning environments as well as lightening their mood and this facilitates greater creativity and boosts student morale and interest. [5]

Game-based learning and gamification is a trend that has been implemented in many settings including workplace training, education, and social media. Many people have been exposed to game-based engagement techniques in one form or another, whether they've been aware of it or not.[6] Game-based learning has proven to be an effective tool in enlightening the pristine minds of children. They provide an interactive learning environment where the child is rewarded, either through in-game progress or achievements, for participating in mentally stimulating activities. Together with the idea of having adequate solutions and technology with game-based learning, it is only acceptable that this study was developed with the right amount of knowledge.

2.1.1   SIMILAR APPS

There have been a handful of games on the environment that have been developed in the past decade. The researchers have selected Clim'Way, Windfall, Recycle City and Sort It Out as the bases of our own game. These games vary on how they each tackle the concepts of waste management and natural resource conservation. This section provides the merits of each and how they affected our creative and analytical choices in the development of the game.

2.1.1.1   CLIM'WAY

The game starts in the year 2008 and by the year 2058, the player should be able to Decrease the use of energy by 40 percent, reduce greenhouse gas emissions by 75 percent and increase the share of renewable energy by 60 percent.

The game expresses the peril of being dependent on nonrenewable energy, the prolonged use of which can lead to large amounts of greenhouse emissions [10]. The game exhibits the potential of games as an E-learning tool [11] breaking down a complex topic [12] such as different types of energy sources and how society should utilize them. [13]

2.1.1.2 **WINDFALL**

The game is all about the player building a wind farm. Utilizing only the wind as the farm's sole energy source. As with Clim'way, Windfall also talks about renewable energy sources. The latter's unique trait, however, is how the reward system incentivizes the player via tracking their progress and rewarding them by points. [14] Moderate rewards in games make players want to play more. [15]

2.1.1.3 **RECYCLE CITY**

The game's objective revolves around the titular city. The player has to help each citizen with their problems regarding proper waste management and disposal, specifically the 3Rs; Reduce, Reuse, and Recycle [16]. Proper waste management has always been a challenge to society [17], even more so in the present and so it is crucial for our game to also impart practical knowledge on how to manage waste [16]

2.1.1.4 **SORT IT OUT**

A rather simpler game, a web-browser game to be specific. It simulates the daily activity of proper waste segregation. The simulation of any human activity has shown to have positive effects on an individual's behavior in certain situations. [18] In our case, we can use our game to simulate what would be mundane daily activities and make the latter engaging through rewards and playful visuals so that we may affect the player's mindset [19] in approaching the issues stated above.

Table 1: Prior Art Feature Similarity and Differences From our Game

Name of The Game	Natural Resource Management	Waste Management	Real-World Application/ Setting	Variety in Gameplay
Clim'Way	★		★	
Windfall	★			
Recycle City		★	★	
Sort it Out		★	★	
Fun ways to Thrive (Researchers' proposed game)	★	★	★	★

3 OPERATIONAL FRAMEWORK

3.1 MATERIALS

3.1.1 SOFTWARE

The game is mainly a Windows Desktop Game. Preferably, for the researchers to make the production possible, the game was compiled using *Unity Game Engine* as it is a very powerful and versatile tool for development and to create a custom background, situations and handle a different kind of touch for the game like; dragging, pinching, swiping. Its features like the visual editor, full robust scripting, the mechanic animation system, and multi-platform build support set for its game engine helped the researchers build it once and deploy.

In preparation for the design, the researchers decided to make use of the pixel-art tool; Aseprite, for the 2D animation because of how efficient and how it can handle canvas and layers effortlessly. This application also has a timeline feature so that you can easily animate your sprites or create sprite sheets. Bosca Ceoil was used for the 8-bit music; It's a tool used for creating music intended for beginners, it has a 5 minutes tutorial before you can use it and its very helpful as for someone who has never produced music or even tunes, it was an excellent entry point.

3.1.2 HARDWARE

The intended computer used has the following specifications: **Processor**: Intel Core i7 with 8gb ram and intel of 4600 HD video card for the integration of the games specified. **Processor**: AMD Ryzen 3; 4 GB DDR 4 Memory with Radeon Vega Mobile Gfx will be used for the game designs and testing.

3.1.3 DATA

This study used data from other environmental projects and video games to determine which methods and actions are the most effective in serving the cause, that is, to spread knowledge and awareness on the aforementioned topics. This study also used various media, such as books, magazines, and pamphlets that discuss these topics to supplement our research.

3.2   METHODS

3.2.1   EXPERIMENTAL DESIGN
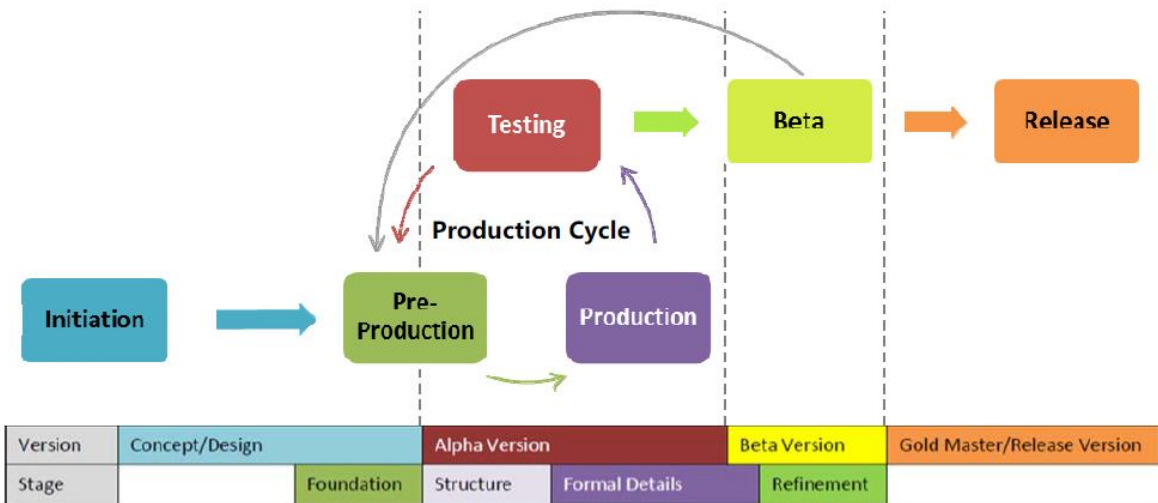
Figure 1 Proposed Game Development Life Cycle

Game development, in general, requires a more specialized approach. The traditional Software Development Life Cycle (SDLC) may prove to be inadequate as game development requires multiple iterations of analysis, implementation, and testing. [6] With the former statement in consideration, the researchers have decided to adopt the Game Development Life Cycle Model [5] in the hopes of achieving a more polished game at the end of this research.

The proposed game allows to directly assess users on a game they can participate in the simulation. They can have their own pace of learning and play in their environment anytime, thus, we intend to develop a collection of mini-game with the easement of these 6 phases.

3.2.2   PROCEDURES FOR THE DIFFERENT PHASES

A. Phase 1: Initiation – Its where the researchers came up with the core gameplay and mechanics of the game, as well as its story and theme then regulated and identified all necessary components for the game introduced.

B. Phase 2: Pre-Production - This phase was centered on the development of the separate game states.

C. Phase 3: Production - A blueprint of the game was created, consisting of six steps to select and define design specifications, for instance, game elements, techniques, a format, and a way to report on the design.[22] The researchers had different mini-games integrated into one seamless flow. When there was a problem with the integration, the researchers would then go back to *Pre-production*. In the creation of the game the researcher used; Unity eLearning Real World Application to create a custom background, situations and handle different kinds of touch (*refer to figure 2 for sample games*). Pixel art and 8-bit music were used for game assets; *Aseprite* (*see Software & Game Design for further discussion of the implementation*) for designing imagery and captivating scenes that are reminiscent of the 90s and 80s style of pixel games [23] and *Bosca ceoil* for the 8-bit music.

D. Phase 4: Testing - A prototype was built, tested, modified, and technically evaluated until the game was considered finished. The play-states then were tested by the researchers as well as other colleagues, younger siblings, and relatives. When there were issues with the flow of the game state, researchers would then go back to the *Production phase.*

E. Phase 5: Beta - In this phase, the game was supposed to be tested by a select group player, or *beta testers,* to see if the game would have bugs, crashes, and function failures. Further iterations of the game would aim to eliminate these problems [24]. But due to the outbreak, the researchers can only conduct alpha testing.

F. Phase 6: Release – The game is objectively completed.

3.2.3 EVALUATION OR TESTING

The evaluation is varied by questions and conducted upon the game was finished. The game is intended for children ages 7-10; The questions made are reflected in the game. It is for the researchers to be informed of how knowledgeable the kid is on unnecessary consumption, conserving energy, and waste disposal with the help of a pretest. After the game had been fully developed, a post-test then was conducted and had allocated 5 days for the children to play. They were given the same questions as the pretest as seen in *appendix A*, to know if they had gained knowledge and that our objective had been made.

The researchers acquired the questions from a curriculum based article and questionnaire with key answers about the environment and environmental science. Grade-specific questions (see *article* [24]).

3.3   CALENDAR OF ACTIVITIES

Figure 2 List of Tasks

		Name	Duration	Start	Finish
1		**Personal Research of Topic**	**5 days**	**12/2/19 8:00 AM**	**12/6/19 5:00 PM**
2		Topic Research	2 days	12/2/19 8:00 AM	12/3/19 5:00 PM
3		Type of Game and Different Properties	2 days	12/2/19 8:00 AM	12/3/19 5:00 PM
4		Meet-Up with Adviser	1 day	12/5/19 8:00 AM	12/5/19 5:00 PM
5		Possible procedures to create game	1 day	12/4/19 8:00 AM	12/4/19 5:00 PM
6		Sort Game Difficulties	1 day	12/4/19 8:00 AM	12/4/19 5:00 PM
7		Meet-Up with Advicer	1 day	12/6/19 8:00 AM	12/6/19 5:00 PM
8		**Final Paper Conception for the Chosen Topic**	**6 days**	**12/6/19 8:00 AM**	**12/13/19 5:00 PM**
9		Decide what game to choose	1 day	12/6/19 8:00 AM	12/6/19 5:00 PM
10		Research for Prior Art	2 days	12/6/19 8:00 AM	12/9/19 5:00 PM
11		Background of the Study	1 day	12/6/19 8:00 AM	12/6/19 5:00 PM
12		Motivation	6 days	12/6/19 8:00 AM	12/13/19 5:00 PM
13		Procedure Path Decision	1 day	12/6/19 8:00 AM	12/6/19 5:00 PM
14		Meet-Up with Advicer	1 day	12/6/19 8:00 AM	12/6/19 5:00 PM
15		Research on Game Engine	1 day	12/7/19 8:00 AM	12/9/19 5:00 PM
16		Programming Language	1 day	12/7/19 8:00 AM	12/9/19 5:00 PM
17		Objectives	0 days	12/6/19 8:00 AM	12/6/19 8:00 AM
18		Meet-Up with Advicer	1 day	12/9/19 8:00 AM	12/9/19 5:00 PM
19		**Production Phase (Blueprint)**	**2 days**	**12/9/19 8:00 AM**	**12/10/19 5:00 PM**
20		Finalizing Art Style	2 days	12/9/19 8:00 AM	12/10/19 5:00 PM
21		Game Mechanics	2 days	12/9/19 8:00 AM	12/10/19 5:00 PM
22		Game Scope and Delimitations	2 days	12/9/19 8:00 AM	12/10/19 5:00 PM
23		Title Defense	1 day	12/10/19 8:00 AM	12/10/19 5:00 PM
24		**Production Phase**	**8 days**	**12/10/19 8:00 AM**	**12/19/19 5:00 PM**
25		Project Outline	2 days	12/10/19 8:00 AM	12/11/19 5:00 PM
26		Review of Related Literature	3 days	12/10/19 8:00 AM	12/12/19 5:00 PM
27		Meet-Up with Advicer	1 day	12/13/19 8:00 AM	12/13/19 5:00 PM
28		Operational Framework	5 days	12/13/19 8:00 AM	12/19/19 5:00 PM
29		Meet-Up with Advicer	1 day	12/16/19 8:00 AM	12/16/19 5:00 PM
30		**Game Integration**	**65 days**	**1/3/20 8:00 AM**	**4/2/20 5:00 PM**
31		**Creation of Sprites**	**60 days**	**1/3/20 8:00 AM**	**3/26/20 5:00 PM**
32		Design Sprites	16 days	1/3/20 8:00 AM	1/24/20 5:00 PM
33		Home/ Mainmenu Interface	3 days	3/18/20 8:00 AM	3/20/20 5:00 PM
34		Add GUI	2 days	3/23/20 8:00 AM	3/24/20 5:00 PM
35		Import Model to Unity	2 days	3/18/20 8:00 AM	3/19/20 5:00 PM
36		Meet-Up with Advicer	1 day	3/18/20 8:00 AM	3/18/20 5:00 PM
37		Integrating Questionnaire	2 days	3/20/20 8:00 AM	3/23/20 5:00 PM
38		Compile Into Working Prototype	2 days	3/23/20 8:00 AM	3/24/20 5:00 PM
39		Self-Testing	5 days	3/20/20 8:00 AM	3/26/20 5:00 PM
40		Meet-Up with Advicer	1 day	3/18/20 8:00 AM	3/18/20 5:00 PM
41		Coding	2 days	3/20/20 8:00 AM	3/23/20 5:00 PM
42		Integrating Questionnaire	5 days	3/20/20 8:00 AM	3/26/20 5:00 PM
43		Meet-Up with Advicer	1 day	3/18/20 8:00 AM	3/18/20 5:00 PM
44		Self-Testing	3 days	3/27/20 8:00 AM	3/31/20 5:00 PM
45		Bug-Fixes	1 day	3/19/20 8:00 AM	3/19/20 5:00 PM
46		Coding	10 days	3/20/20 8:00 AM	4/2/20 5:00 PM
47		**Final Testing**	**53 days**	**3/20/20 8:00 AM**	**6/2/20 5:00 PM**
48		Final Bug-Fixes	9 days	3/20/20 8:00 AM	4/1/20 5:00 PM
49		Monitor Game Outcome	7 days	4/2/20 8:00 AM	4/10/20 5:00 PM
50		Final Compile	25 days	4/2/20 8:00 AM	5/6/20 5:00 PM
51		Final Evaluation	19 days	5/7/20 8:00 AM	6/2/20 5:00 PM

4   RESULT OF PRE-TEST AND POST-TEST

Table 2 Pretest and Post-test Result Chart

No. of Respondents	No. of Questions	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	TOTAL REMARKS
P1 (10)	AL-AL																	
	PRE-TEST	/	/	/	/	/	/	/	/	/	/	×	×	/	/	/	/	14
	POSTTEST	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	16
P2 (10)	Sara																	
	PRE-TEST	×	/	/	/	/	/	/	/	/	/	×	/	/	/	/	/	14
	POSTTEST	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	16
P3 (7)	Sehr																	
	PRE-TEST	/	/	/	/	/	/	/	/	×	/	×	/	/	/	/	/	14
	POSTTEST	/	×	/	/	/	/	/	/	×	/	/	/	×	×	/	×	11
P4 (6)	King																	
	PRE-TEST	×	×	×	/	/	×	/	×	/	×	×	×	/	/	/	/	8
	POSTTEST	/	/	/	/	/	×	×	/	×	×	×	×	/	×	/	/	9

The table above shows simpler dissemination of total number of respondents and their scores for both pre-test and posttest.

5   DISCUSSION

Discussion about proper conservation and its impact on the environment revealed that particular users had some previous knowledge about the issue before the pretest. The kids were asked questions about obvious practices to conserve at home like "What should you do if you see or hear a leaky faucet in your house?" where most of them got it right but when asked with questions "What are the things that can be recycled?" or "Which of the answers describes something you can do to conserve energy?" the kids were unsure. The game was designed not only to teach the impact of conservation and waste management but also to bring about change in children's behavioral patterns in regards to the conservation of their environment. The practical test with the game revealed significantly gradual changes in terms of the learning process of a kid although considering that the researchers had only accumulated 5 days for the kids to play the designed game made the effectiveness of it provable; sequence to understanding that learning while playing can come off cumulatively.

The result shows the benefits of technology as a learning habit. These educational games are more and more considered as new instructional technology with great potential (Becker, 2007) and are hypothesized to effectively aid instructional purposes because they (theoretically) provide diverse approaches that can address cognitive and affective learning e.g. knowledge construction, skills and attitudes acquisition. [27]

Average	Median	Range
12.25/16 points	14/16 points	7-14 points

Total points distribution
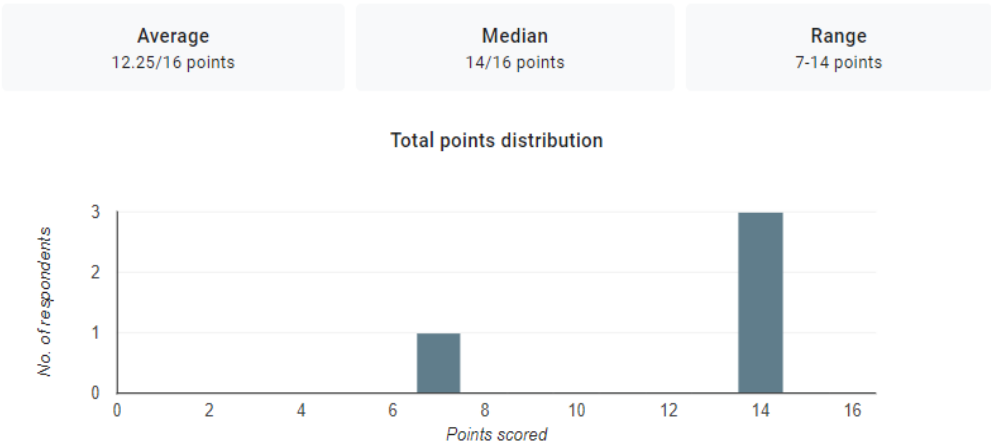
Figure 3 Graphical View of Pre-test Result

Average	Median	Range
13/16 points	11/16 points	9-16 points

Total points distribution
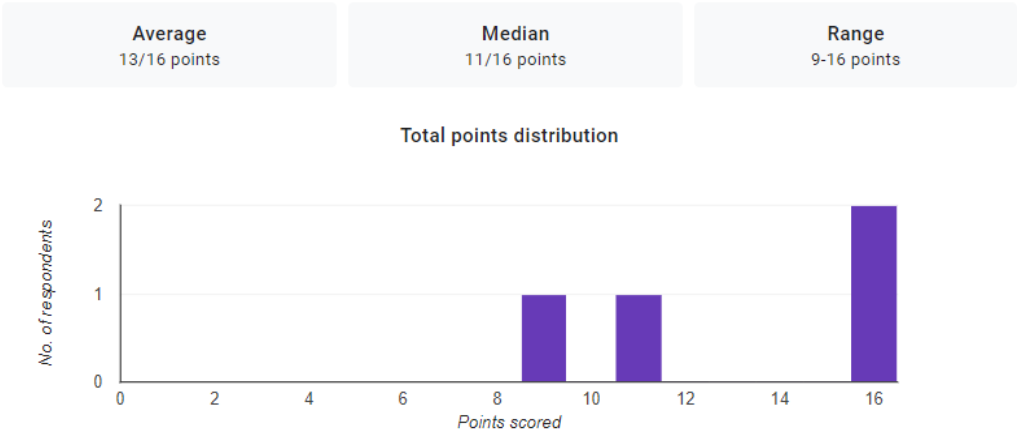

Figure 4 Graphical View of Post-Test Result

What is your name?

4 responses

Sehr R. Yaqub

Sara R. yaqub

al al

king jason

Figure 5 Respondent's Name

Figure 6 Respondents' while Taking Pre and Post Test

Timestamp	Score	What is your name?
16/05/2020 12:34:32	14 / 16	Sara R. Yaqub
16/05/2020 12:44:43	14 / 16	Sehr R Yaqub
21/05/2020 15:29:37	7 / 16	King Ronda
27/05/2020 17:45:58	14 / 16	Andrew

Table 3 Pre Test Responses Sheet

Timestamp	Score	What is your name?
29/05/2020 15:32:06	16 / 16	Sara R. yaqub
29/05/2020 15:34:06	16 / 16	al al
29/05/2020 15:43:24	11 / 16	Sehr R. Yaqub
29/05/2020 15:57:53	9 / 16	king jason

Table 4 Post Test Responses Sheet

TECHNICAL OBSERVATION

→ The player is more focused when the game has a faster pace.

→ The player takes about 7-15 seconds to read the trivia in between games.

→ Takes about 2-5 iterations of the trivia for the player to remember them.

→ Not all trivia can be encountered in one playthrough, thus promoting multiple playthroughs.

→ Limiting the controls to the mouse gave the player faster reaction time.

→ 1st playthrough of the game may confuse the player (if said player is not able to react to the instructions in time). Subsequent playthroughs, however, have shown improvement in terms of score and completion time.

Figure 7 Respondent while playing Fun Ways To Thrive

6   CONCLUSION

This research that has been proposing awareness and studies on how effective game-based learning circles around children; It's a time where we learn new concepts quickly and where the brain soaks up all the information it receives. The result of this research conveyed that children have eyes that are curious and are always equipped with questions "why" or "how" when being taught something new. Exactly why adults have a bigger responsibility for teaching younger generations about the environmental issues we are facing right now and must lead by example. It has to be adults who start the conversation, but with the rapid change caused by technology, it becomes unyielding to interact with them.

The developed game served as a starting point for us adults to impose such issues with the younger ones. Children are already fond of anything that goes on the screen, and so the researchers took advantage of that and made a game that provides knowledge on how to conserve and help mother nature.

The mere fact that adults and children can practice and be aware of their actions after playing the game gave justice to this study. The game served its purpose as a campaign game on forming a healthier and safer environment by judging the changes of behavior of our younger siblings and comparing the results of the pretest and posttest.

The thing about research is it's not just about cultivating new ideas, it's also about leaving an impression and being impactful. The researchers trusted how a simple idea can be impactful with the right amount of knowledge and study, but ideas are not enough. Anyone that reads this research must remember that ideas need to be channeled into the real world to make a difference and for that idea to manifest.

7 RECOMMENDATION

Based on the findings, the following recommendation is formulated:

1. This method of teaching may be used for further study of how children respond with learning through video games.

2. It is highly probable that a better pretest and posttest would've been made if there were enough kids and days to test but because of the pandemic, another further analysis will have considerably better results.

3. Additionally, a thorough study on the topic at hand is recommended that can supplement the game elements and that can take different playthroughs.

4. A research study on how to improve spreading awareness should be conducted with a wide age group to promote to; possibly can add mini-games that different age categories can enjoy.

8   THE SYSTEM: OVERVIEW OF FUN WAYS TO THRIVE

The goal is to determine and develop a game that can enhance the knowledge of users in forming a healthier and safer environment through game-based learning.

GAME STATE

- In the first state, the game starts up. In this state, a background and a play button shall display. Then the game state changes to 1.
- In the second state, after the introduction, the screen displays the first quiz then proceeds to the first game then changes to 2.
- In the third state, after the quiz, the first game shall start with the time limit (depending on the situation given) then the game changes to 4.
- In the fourth state, a player's life is displayed, the game changes to 5.
- In the fifth state, the game is over.

PROGRESSION

→ Difficulty and time-frame depends on the game

PEDAGOGY (STRATEGY OF TEACHING)

→ Repetition

GAME DESIGN

The game was inspired by the famous game *Dumb Ways to Die*. The idea of how the game would be played was derived from it but the aspect and topic projected made the difference. *Dumb Ways to Die* used flat design for their theme but the researchers didn't want to fully commit to the game genre of *Dumb Ways*, thus decided to bring back retro styles and used pixel art.

The game design was made possible with *Aseprite (read software section for further description).*

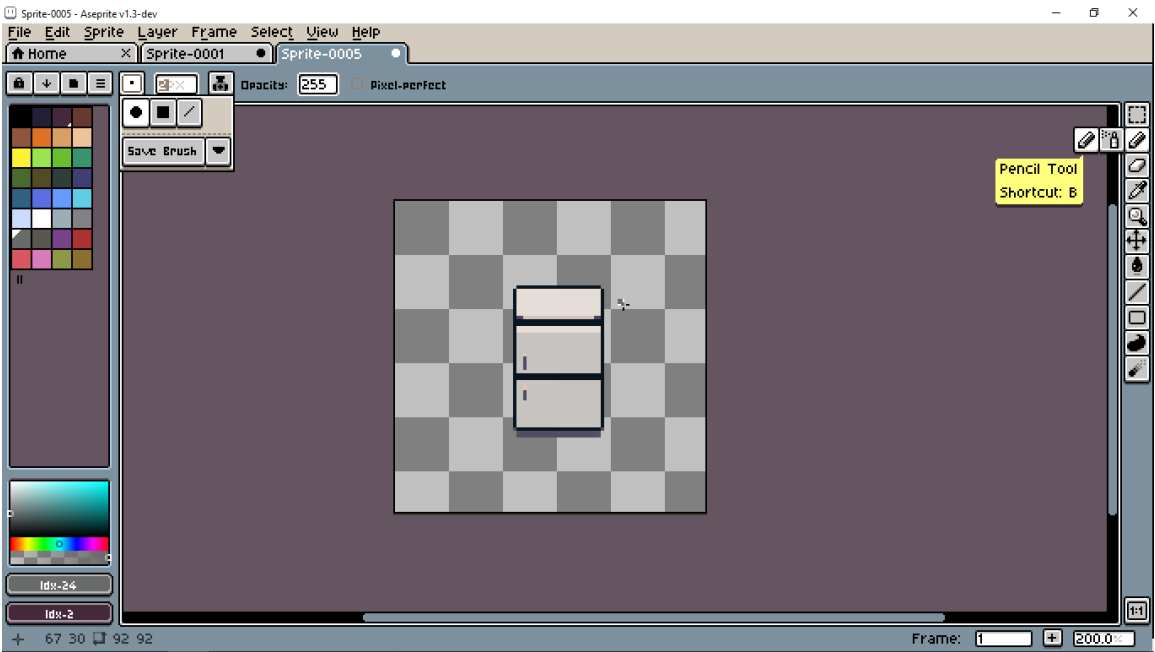**Figure 8 Sample Game Entity Used in the Game; Made in Aseprite**

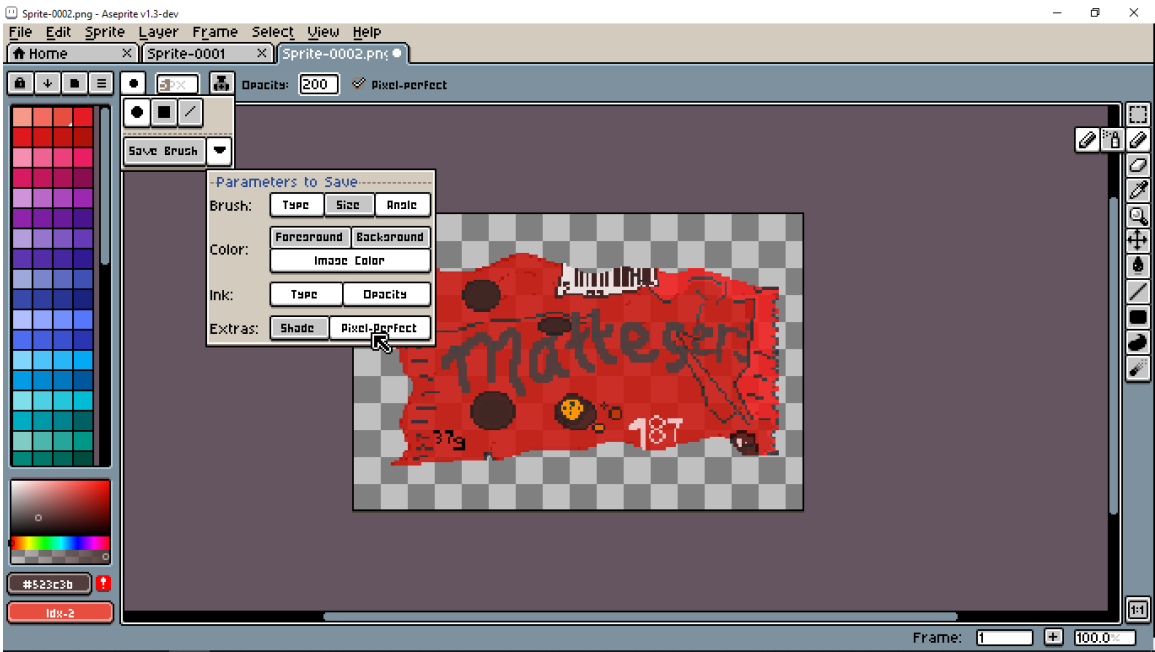**Figure 9 Researchers' Prospect of Making Entities in Aseprite**

Figure 10 Researchers' Prospect of Making Entities in Aseprite
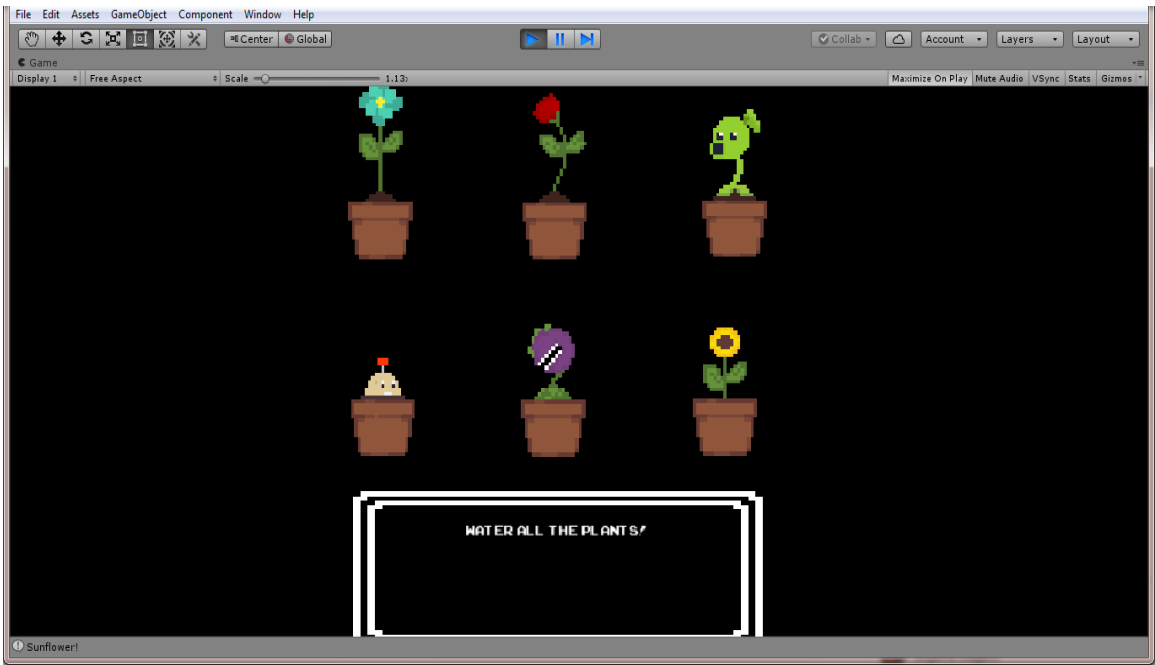

Figure 11 Prospect of the Researchers' in Unity

GAME PLAY

Figure 12 Title Screen

Figure 13 Trivia Screen

Figure 14 1st Play State

Figure 15 2nd Play State

Figure 16 3rd Play State

Figure 17 4th Play State

Figure 18 5th Play State

Figure 19 6th Play State

Figure 20 Success State

Figure 21 Fail Screen

SOFTWARE

The game is mainly a Windows Desktop Game. Preferably, for the researchers to make the production possible, the game was compiled using Unity Game Engine as it is a very powerful and versatile tool for development and to create a custom background, situations and handle a different kind of touch for the game like; dragging, pinching, swiping. Its features like the visual editor, full robust scripting, the mechanic animation system, and multi-platform build support set for its game engine helped the researchers build it once and deploy.

In preparation for the design, the researchers decided to make use of the pixel-art tool; Aseprite, for the 2D animation because of how efficient and how it can handle canvas and layers effortlessly. This application also has a timeline feature so that you can easily animate your sprites or create sprite sheets.

To have unique 8-bit music for the game, the researchers decided to use Bosca Ceoil; It's a tool used for creating music and is intended for beginners, it has a 5 minutes tutorial before you can use it and it's very helpful as for someone who has never produce music or even tunes, it was an excellent entry point.

HARDWARE

The intended computer used has the following specifications: Processor: Intel Core i7 with 8gb ram and intel of 4600 HD video card for the integration of the games specified.

Processor: AMD Ryzen 3; 4 GB DDR 4 Memory with Radeon Vega Mobile Gfx will be used for the game designs and testing.

REFERENCES

[1]   S. L. Flower, "Environmental Challenges in the 21 st Century," vol. 9, no. 4, pp. 248–252, 206AD.

[2]   Z. Sabarinah, "The Importance of Waste Management Knowledge to Encourage Household Waste-Sorting Behaviour in Indonesia," *Int. J. Waste Resour.*, vol. 07, no. 04, 2017.

[3]   T. Connolly and M. Stansfield, "Using Games-Based eLearning Technologies in Overcoming Difficulties in Teaching Information Systems," *J. Inf. Technol. Educ. Res.*, vol. 5, pp. 459–476, 2006.

[4]   P.-M. Noemí and S. H. Máximo, "Educational games for learning," *Univers. J. Educ. Res.*, vol. 2, no. 3, pp. 230–238, 2014.

[5]   D. Kirkland and F. O'Riordan, "Games as an Engaging Teaching and Learning Technique: Learning or playing ?," *Nov. Approaches to Promot. Student Engagem.*, pp. 77–87, 2008.

[6]   E. Z. F. Liu and P.-K. Chen, "The Effect of Game-Based Learning on Students' Learning Performance in Science Learning – A Case of 'Conveyance Go,'" *Procedia - Soc. Behav. Sci.*, vol. 103, pp. 1044–1051, 2013.

[7]   E. Mohamed, "Environmental Education and Public Awareness," *J. Educ. Soc. Res.*, no. July 2006, 2014.

[8]   K. Shimada, "Efficiency Evaluation of Philippines Waste Management Sector : A Two-Stage Approach," no. March 2014.

[9]   A. Pho and A. Dinscore, "Game-Based Learning Overview and Definition," *Tips Trends Instr. Technol. Committee*, no. Spring 2015, pp. 1–5, 2015.

[10]   G. George, S. Schillebeeckx, and T. L. Link, "The management of natural resources: An overview and research agenda," *Acad. Manag. J.*, vol. 58, no. 6, pp. 1595–1613, 2015.

[11]   A.-M. Tîrziu and C. Vrabie, "Education 2.0: E-Learning Methods," *Procedia - Soc. Behav. Sci.*, vol. 186, no. October 2014, pp. 376–380, 2015.

[12]   S. Schack and K. Foundation, "The Effectiveness of E-Learning : An Explorative and Integrative Review of the Definitions, Methodologies, and Factors that Promote e-Learning Effectiveness ResearchLAB : IT and Learning Design, Dep . of Learning and Philosophy, Aalborg," *Electron. J. e-Learning*, vol. 13, no. 4, pp. 278–290, 2015.

[13]   S. Tang, M. Hanneghan, and A. El Rhalibi, "Introduction to games-based learning," *Games-Based Learn. Adv. Multi-Sensory Hum. Comput. Interfaces Tech. Eff. Pract.*, no. October, pp. 1–17, 2009.

[14] H. Wang and C. T. Sun, "Game reward systems: Gaming experiences and social meanings," *Proc. DiGRA 2011 Conf. Think Des. Play*, no. March 2011.

[15] J. Malala, A. Major, J. Maunez-Cuadra, and P. McCauley-Bell, "The Use of Rewards in Instructional Digital Games: An Application of Positive Reinforcement.," *Online Submiss.*, no. 2005, 2007.

[16] F. A. Rahman, "Reduce, Reuse, Recycle : Alternatives for Waste Management," *NM State Univ.*, pp. 1–4, 2000.

[17] M. A. A. Branco *et al.*, "Games no contexto Ambiental e seu uso estratégico para educação Ambiental," *Brazilian J. Biol.*, vol. 75, no. 2, pp. S114–S121, 2015.

[18] A. De Gloria, "Preface," *Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics)*, vol. 9599, no. November 2017, pp. V–VI, 2016.

[19] A. W. Utoyo and M. Sn, "Video Games as Tools for Education," *J. Game, Game Art Gamification*, vol. 03, no. 02, pp. 0–6, 2018.

[20] R. D. Duke, "Origin and evolution of policy simulation: A personal journey," *Simul. Gaming*, vol. 42, no. 3, pp. 342–358, 2011.

[21] R. Kortmann and C. Harteveld, "Agile game development: Lessons learned from software engineering," no. September 2014.

[22] T. Wulf, N. D. Bowman, D. Rieger, J. A. Velez, and J. Breuer, "Video games as time machines: Video game nostalgia and the success of retro gaming," *Media Commun.*, vol. 6, no. 2, pp. 60–68, 2018.

[23] C. Redavid and A. Farid, "An Overview of Game Testing Techniques," *Idt.Mdh.Se*, pp. 179–198, 2011.

[24] J. Easton, "Reduce, reuse, recycle," *Min. Mag.*, no. SEP, pp. 8–9, 2014.

[25] R. Ramadan and Y. Widyani, "Game development life cycle guidelines," 2013 Int. Conf. Adv. Comput. Sci. Inf. Syst. ICACSIS 2013, no. June, pp. 95–100, 2013.

[26] F. Wagner, Modeling Software with Finite State Machines. 2006.

[27] S. Vandercruysse, M. Vandewaetere, and G. Clarebout, "Game-based learning: A review on the effectiveness of educational games," *Handb. Res. Serious Games as Educ. Bus. Res. Tools*, no. February 2014, pp. 628–647, 2012, DOI: 10.4018/978-1-4666-0149-9.ch032.

APPENDICES

APPENDIX A: PRETEST AND POSTTEST QUESTIONNAIRE

1. Plastic that is used one time and then thrown away is?

   A. Post-Consumer
   B. Reusable
   C. Recyclable

2. True or False: Keeping the water running when you brush your teeth wastes a lot of water.

   A. True
   B. False

3. Which type of light bulb uses less energy?

   A. LED
   B. Fluorescent
   C. Lamp

4. Paper products that are used one time and then thrown away are?

   A. Post-Consumer
   B. Reusable
   C. Disposable

5. What should you do if you see or hear a leaky faucet in your house?

   A. Ignore it—drips are no big deal

   B. Do nothing—there is no way to fix a drippy faucet

   C. Tell your parents

6. Which of the answers describes something you can do to conserve energy?

   A. Turn off the lights when you leave the room.

   B. Iron your clothes sparingly

   C. Regulate the use of smartphones

   D. All of the above

7. Which of the following is clean and renewable energy?

   A. Solar Energy
   B. Fossil Fuel
   C. Coal

8. Do you know what the 3Rs are?

    A. Reduce, Redeem & Reply
    B. Reduce, Reuse & Recycle
    C. Recycle, Reborn & Replay

9. Which of these is a good example of reusing instead of throwing something away?

    A. Using plastic bottles as water containers
    B. Using plastic bottles as makeshift pots for plants
    C. All of the Above

10. What does it mean to reuse?

    A. To use again the things in a different way
    B. To make something smaller or useless
    C. To compose a waste

11. Which material should be put into the brown bin?

    A. Paper bag
    B. Leftover food and out of date food
    C. Glass Bottle

12. What are the things that can be recycled?

    A. Newspapers, Aluminum tins, Plastic bottle
    B. Paper, paint, orange
    C. Plastic bags, Glass bottle, candy

13. Why should we practice 3R?

    A. To destroy the Earth
    B. To conserve our environment
    C. To produce pollution

14. Who is responsible for conserving our environment?

    A. Students
    B. Teachers
    C. Parents
    D. All

15. What does it mean to reduce?

    A. Make something into something new.
    B. Use less of something, creating smaller amounts of waste.
    C. Make something ugly into something beautiful.

16. Which of the following is bad for the environment?
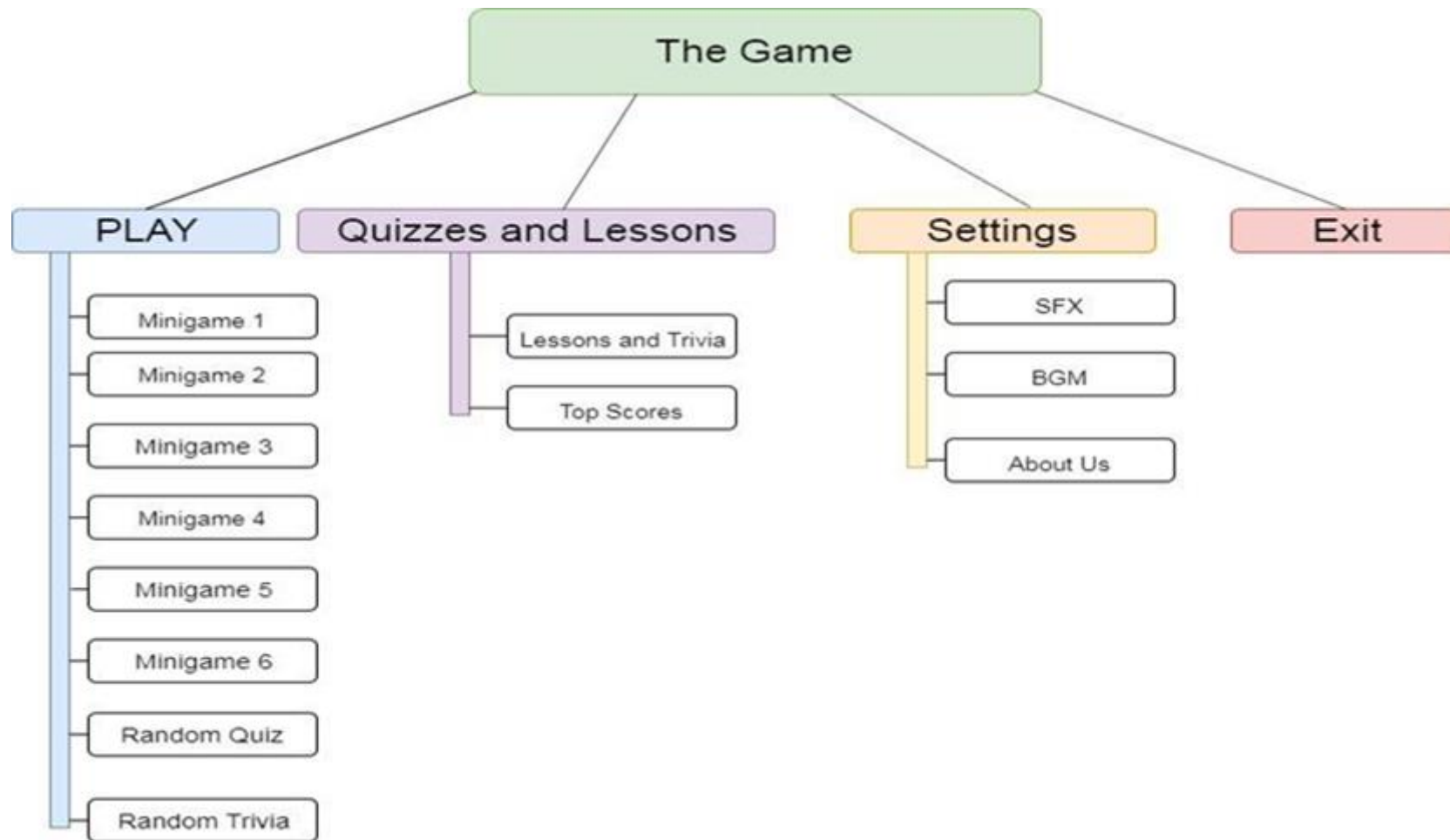
    A. Recycling
    B. Littering
    C. Reducing
    D. Reusing

Figure 22 Fun Ways to Thrive Hierarchical Structure