PUBLIC AWARENESS THROUGH GAME-BASED LEARNING

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Declaration

I declare that this is my own work and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of the supervisor: Date

……………………………   …………………..

   Dr. Windhya Rankothge

Abstract

There are a lot of environmental pollution-related problems faced by Sri Lanka right now. Garbage pollution is one of the most widespread social and environmental problems. Most of the time people directly involved in polluting the environment. People in our country have no idea about how to effectively dispose of garbage. Perhaps people deliberately dispose of the garbage improperly or they may not know how damage to the environment is done by improper disposal of the garbage. According to information obtained from the divisional secretariat, improper disposal of waste is an offense common to all age groups. There are various programs to aware people of environmental pollution in our country but none of them have delivered successful results. As a solution, an awareness gaming platform has been developed to aware of the public about garbage disposal issues using 2D, 3D, and virtual reality technologies.

Keyword: Awareness game, Garbage disposal, Virtual reality

ACKNOWLEDGEMENT

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List of Abbreviation

Abbreviation	Description
MSW	Municipal Solid Waste
LA	Local Authority
VR	Virtual Reality
MT	Metric Ton

1 INTRODUCTION

1.1 Background

Pollution from garbage is one of the most widespread social and environmental problems. In this section, what the pollution due to garbage is explained and describe the various types of garbage and also explain the causes, sources, and effects of the waste. In the context of waste disposal, the man-made waste is mainly concerned. Each type of garbage has a specific contribution to and effect on the pollution due to the garbage. There are many types of garbage that can be disposed to the environment by a single person. They are organic waste, paper wastes, glass, bottles, metals, coconut shells, plastics, polythene, E-waste. Due to human negligence improper disposal of garbage has caused and it caused great harm to the environment

The management of solid garbage disposal has currently become one of the major issues in Sri Lanka. Sri Lanka generates 7,000 MT of solid waste per day. Of that amount, the Western Province accounts for nearly 60 percent of waste generation. Every individual generates an average amount of 1- 0.4 kg of waste per day. The Waste Management Authority and the Central Environmental Authority report that only half of the waste generated is collected [1].
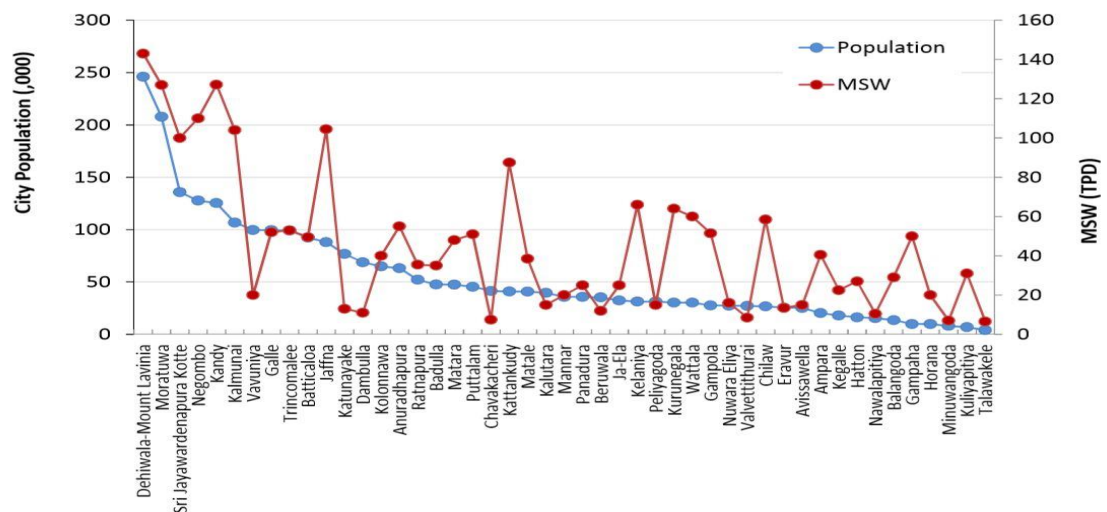
Figure 1.1: Populations and waste collection in LAs of Sri Lanka

As shown in Figure 1.1, the study revealed that the amount of waste generation in 68 cities except for five major cities including Colombo MC is less than 40 Tons per day (TPD) [2]. In Sri Lanka, waste collection and disposal responsibilities are vested with the local authorities of the particular Divisional Secretariat, either a municipal council, urban council or local council.

Sri Lanka is faced with huge problems due to garbage. As an example, part of the Meethotamulla garbage dump mountain recently suddenly collapsed. Taking 30 human lives toll as of 16-04-2017, this disaster had left 1,500 homeless and displaced families [3]. Not properly disposing of garbage can also harm human health. Through these activities, individuals are exposed to various diseases.

The Government of Sri Lanka has paid close attention to proper disposal and recycling of garbage in various situations. Figure 1.2 demonstrates some plans and policies / Solid Waste Management Strategies [4].

Year	Policy & Regulation	Description
2000	National Strategy for Solid Waste Management (NSSWM)	■ 3-years action plan, Waste reduction, 3R implementation
2003	Caring for Environment Phase I (2003-2007) Phase II (2008-2012)	■ Funded by United Nations Developing Program; UNDP ■ National Environmental Action Plans
2005	Vision for A New Sri Lanka	■ A Ten Year Horizon Development Framework 2006-2016 formulated by Ministry of Finance and Planning ■ Solid waste and pollution management included in the investment plan
2007	National Policy on Solid Waste Management	■ Waste reduction, 3R implementation, Sanitary landfills ■ Capacity building, Research and development (Best Available Technologies (BAT), Best Environmental Practices (BEP)
2008	Pilisaru Programme Phase I(Jan. 200 –Dec. 2013) Phase II(Jan. 2014–Dec. 2018)	■ National level programme for solid waste management under the chairmanship of Ministry of Environment, CEA, and others. ■ Initial budget amount: 5.675 bil LKR. ■ Target is to introduce small and medium waste treatment system in all local government authorities by year 2018 and to cover 50% by year 2016.
2009	National Action Plan for Haritha Lanka Programme	■ Establishment of National Council for Sustainable Development (NCSD) ■ Sustainable development: Harita (Green) Lanka Programme

Figure 1. 2: Plans and Policies/Strategies related to Solid Waste Management

The "Pilisaru" program is a good example of how to aware people of the garbage disposal properly. "Pilisaru" program includes several activities. They are Project coordinated awareness campaign on waste segregation at Local Authority level, monitoring, and evaluation, conduct education and awareness programs and providing the local authorities with adequate waste management facilities. And objectives of the "Pilisaru" program is Preparation of national policy on Solid Waste management and strategies for solid waste management [5].

Furthermore, the Solid Waste Management Unit was established on 01.06.2018 in the Waste Management Division with the objective of creating a safe and healthy environment through the efficient and successful implementation of waste management systems in the country. The Solid Waste Management Unit has three key cells: Policy & Technical Interventions, Implementation & Regulation, and Implementation of Special Projects related to Solid Waste Management.

Considering the data here, it is clear that man has caused damage to the environment through garbage. From the above it can be seen that many people have tried to minimize the damage to the environment by conducting various awareness programs from time to time. But today, the pollution caused by garbage does not seem to be decreasing not only in Sri Lanka but all over the world.

1.2 Literature survey

This section explains various systems that have been created in the world to educate people on environmental pollution. Nowadays, with new technology, people tend to do their daily activities. A lot of knowledge about various aspects can be obtained through the internet. Nowadays, people are becoming more and more knowledgeable about different areas as well as technology has created the ability to reach people quickly. People can acquire knowledge through many things like articles, videos, audio, images, and advertisements. Basically, the game plays a big role among the people. The game is used to educate the public about environmental issues such as garbage disposal

Trash Attack [6]**.**

This game focused on creating a platform for promoting environmental education, encouraging a sense of connection to the natural world, encouraging the protection of irreplaceable natural resources and raising awareness about the environment. It was built as a video-game action puzzle. Trash Attack is a 2D-based video game that people make aware of Biodegradable waste, non-biodegradable and recyclable wastes.

The development of the game was composed of four levels. The first stage was prototyping where a functional game prototype was created by the team with all the main gameplay elements and assets required to make the game playable. The second stage of development was the Alpha stage, where it achieved continuous testing of output. During this point, more assets have been developed and there have been changes as imagined by the game designer, to be done in preparation for the next sprint. Next was the Beta stage, where users outside the development team tested the beta version game build as a result of the alpha stage to provide user feedback and information in order to further improve the game, as well as insights into any issues that the development team had missed during the alpha stage. Ultimately, the final stage was where game developers submitted final changes for the assets and improvements needed to be made to fix major found issues during beta testing to prepare the game for the final release.

The proponents developed the video game through the use of Unity Engine, Photoshop, Illustrator, Autodesk Maya, and other multimedia editing applications across a span of three to four months. Thirty-six respondents evaluated the game and proved the following points in the game evaluation

- That the game promotes environmental awareness while being entertaining and engaging
- That the game worked efficiently while running showing little or no problems with the frame rate and causing players minimal inconvenience
- That the game was successfully ported to mobile devices enabling everyone to play and learn

Figure 1. 3: Trash Attack Waste Segregation Screen

Attack of the Recyclops [7]

This research has shown that educational gaming can involve students in the learning of a wide range of cognitive processes, from simple memory to complex problem-solving. In particular, the research team set out the goal of creating a game of educational virtual reality, designed to improve responsible waste management learning.

The research team built a virtual reality educational game, Attack of the Recyclops to examine its effect on undergraduate student learning and pro-environmental behavior. The learning goal put forward by the research team is that the player must know how to choose

the right disposal avenue for different types of waste at the conclusion of the gameplay. The objective of the research is that at the end of the gameplay the player will learn how to choose the correct disposal way for different types of wastes. The Oculus Rift is the VR headset that the team will be using. The researchers will position the player within a virtual campus with this headset, and the player will be able to explore the campus and learn about the importance of waste management.

The team, using previous research, leveraged the revised Bloom's Taxonomy of educational goals to establish the learning outcomes for Attack of the Recyclops game. In the first version of the taxonomy, Bloom points out three areas for learning assessment objectives: cognitive, affective, and psychomotor. The cognitive domain in the revised taxonomy edition ranges from lower to higher-order thinking abilities. This research developed using Unity game engine, virtual reality (VR), 3D, 2D models, and photorealistic graphics and JavaScript technologies.
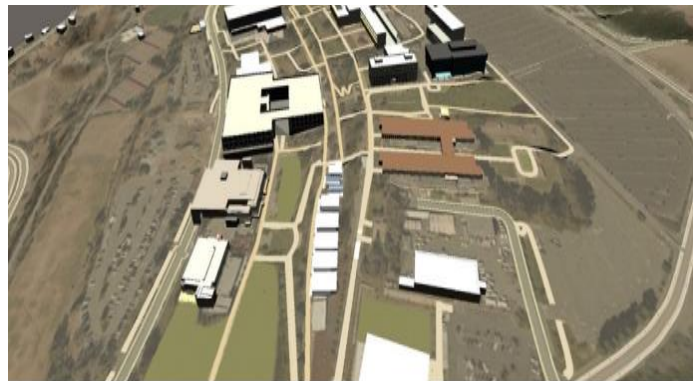
Figure 1. 4: Virtual Campus in Unity 3D

reCyCLOR [8]

ReCyCLOR targets mainly elementary-age children aged 9-11, males and females Children who are still exceptional on environmental issues and more vulnerable to behavioral change or impact and probably in areas where recycling programs and facilities are already in place. ReCyCLOR targets mainly primary-age children between 9 and 11 years of age, male and female children that are still impressionable on environmental issues and are more susceptible to behavioral change or impact, they probably in areas that already have recycling schemes through infrastructure in place.

This is a fast-paced game aimed at improving the processing and cognitive skills of the players over time. In the real world environment, the knowledge and skills acquired in the game hopefully form positive actionable habits.

Figure 1. 5: Collecting Garbage

iTrash [9]

The study created an educational Android game app to train young people 3 years and older to recognize their minds properly. Through this mobile game app, the user learns the basic separation processes that are common in the environment. It was concluded that the application. Compatible with Gingerbread 2.3.1, it runs on Lollipop version 5.0.2 and above. The mobile app is designed for kids ages 4 to 5. This range is very active in learning lessons related to educational mobile games. Separation of waste between biodegradable and non-biodegradable materials. This game requires knowledge according to waste classification so kids who play this game will need to learn a lot before going. Figure 1.6 shows a classroom level screenshot. At this level, the child will learn to segregate and identify school waste.

Figure 1. 6: Classroom Level

1.3 Research Gap

As shown in Table 1.1, most of the completed research is based on 2D technology. Games have been used to educate the public about different types of garbage and disposal. Also, many games are designed to enhance the various user abilities of the game. But the capabilities that need to be improved in the game appear to be games created without prior data collection or analysis.

Table 1. 1: Differences between proposed project and other Systems

Researchers / Features	Trash Attack	Attack of the Recyclops	reCyCLOR	Proposed Project (AwareME)
Segregation of garbage	✓	✓	✓	✓
Proper waste disposal	✗	✗	✓	✓
Improve user ability	✗	✓	✓	✓
Virtual reality / 3D	✗	✓	✗	✓
2D	✓	✓	✓	✓

The proposed system we developed under 2D, 3D and virtual reality (VR) technology. The main research part of the proposed gaming platform is to create the best game to improve user abilities. First, the data must be collected and analyzed before the game can be created. The specialty of this game is to collect data and after identify abilities through it. Many games are designed based on small children. But the proposed gaming platform we developed games for young children as well as adults. According to this environmental awareness game, it mainly focuses on waste disposal management. It has been decided to create games under environmental pollution, garbage disposal, and garbage collection.

But most of the other games using segregate garbage and proper garbage disposal. Table 1.2 shows analysis with other products and AwareMe product.

Table 1. 2: Research gap analysis

Research	Covered from other studies	AwareME
Environmental Awareness gaming platform	• The games focus on children	• The game focuses on both adults and children
Improving abilities from the game	• Ability identify after playing the game	• Gather data and come to a conclusion about the abilities that need to be developed through it
Choose best game for awareness	• Developed games without any data collection	• Choosing the best game by collecting data
The knowledge given through games	• Used Garbage disposal properly and Segregate garbage	• Used Garbage disposal properly, Segregate garbage and environmental pollution • Creating game content by collecting data and testing knowledge

1.4 Research Problem

Garbage disposal is one of the most serious environmental problems faced by Sri Lanka at present. It is difficult to imagine a pleasant environment where there is no unpleasant garbage heaped everywhere. Garbage generation levels are rising day by day. Sri Lanka generates 7000 MT of solid garbage per day with the western province accounting for almost 60 percent of garbage generation. Each person produces an average of 1-0.4 kg of garbage a day

Municipal councils and government institutions have attempted to figure out a solution for garbage disposal in past decades. By not properly disposing of garbage, the damage to the environment is increasing day by day. These activities also pose a threat to human health. Disposal of garbage inappropriately is a practice of all ages. The reason for this negative attitude is lack of awareness and lack of successful education program to educate the people about the social responsibility of each citizen in keeping the environment clean. Even though there were many programs have been implemented on environment pollution and garbage disposal, unfortunately it has failed to find out permanent solution to the garbage disposal. By using modern technology and creating awareness on environmental pollution among people and convincing the impact of such environmental pollution to human being, this garbage problem can be mitigated to greater extent.

How do we properly recycle the garbage?

What is the right way to educate people on proper disposal of garbage?

1.5 Objectives

1.5.1 Main Objectives

The main objective of this proposed research is to improve the abilities of people making them aware of environmental pollution by using the game-based learning platform.

1.5.2 Specific Objectives

There are some specific objectives in the proposed system,

- **To save the nature by effective awareness on the garbage disposal** - Raising awareness about waste management through a game-based learning platform.

- **To Identifying the audience to collect research related data** - Identifies the age groups that need the knowledge for games implementation

- **To create a standard questionnaire for data collection about the garbage disposal awareness -** Accurate conclusions can be drawn from a standard questionnaire when collecting data

- **According to the data analyzed, to identify how about their knowledge about waste disposal and what are the user abilities can improve using game -** After analyzing the data, select the games that are appropriate for the age group and identify the user abilities that need to be developed from those games. 2D Quiz game to improve thinking ability and recalling ability and, a 3D Action game to improve the decision-making ability

- **To create a perfect game for increasing awareness of the proper disposal of garbage through the proposed awareness game -** Creating age-appropriate games and knowledge development games related to garbage disposal

- **To design interesting interfaces for different age groups and to create games for interest to them -** The appearance of games varies with age. Background images, sounds, and colors should be taken into consideration when designing a game

- **To identify the improvement of the users by testing their awareness level through the gaming platform -** After creating the game, players should be given the opportunity to find out if they have gained knowledge about waste disposal through these games.

2 METHODOLOGY

2.1 System Overview

The overview diagram shows the basic elements of the overall system in our proposed awareness game platform. According to Figure 2.1, it shows four main game functions based on the single platform of the public awareness game called AwareME.
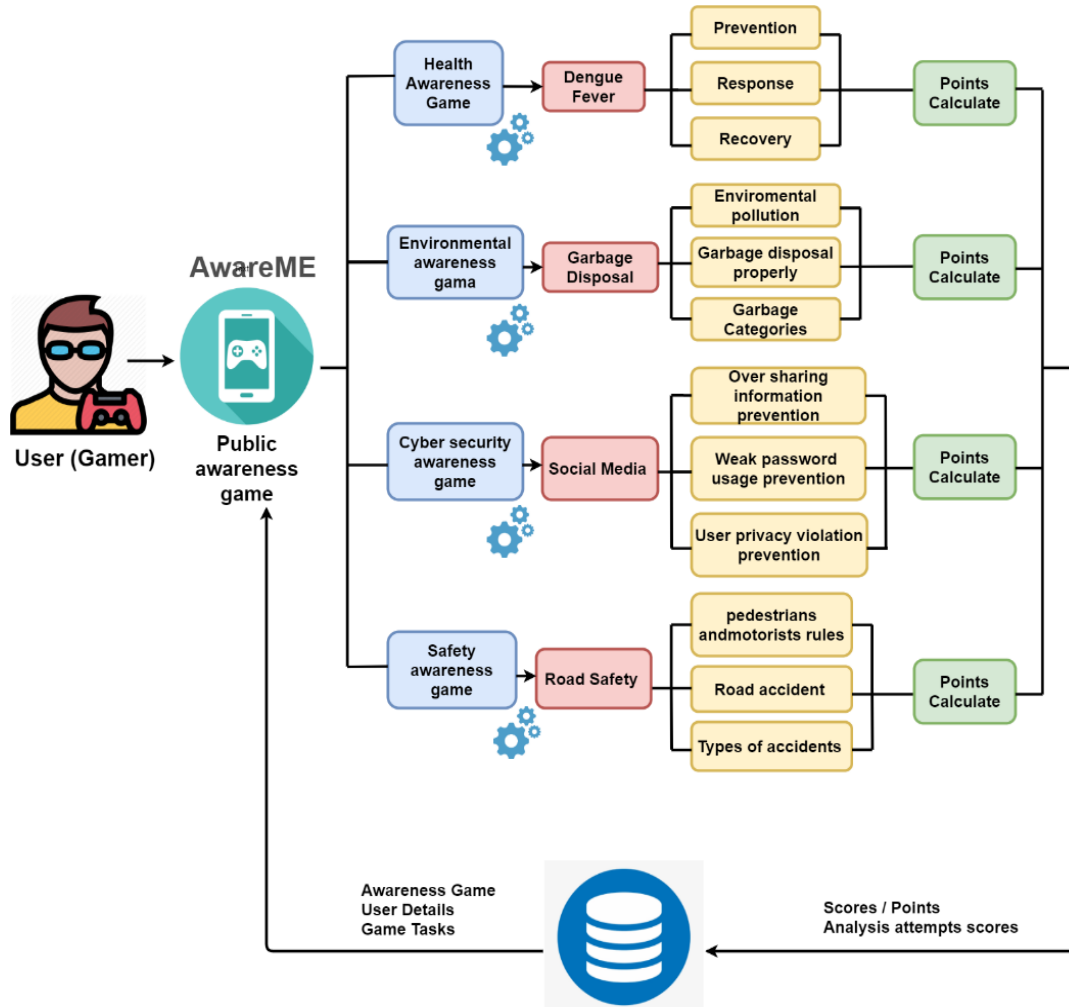
Figure 2. 1: System Overview of Group

First, the user has to register and login to the game. After that user (gamer) has to select one of the awareness games to play. The four main games are split up into several sub-areas. The game will cover all the sub-areas already listed. In this module, the environmental awareness game will mainly focus on garbage disposal awareness.

According to figure 2.2 garbage disposal games also divided into three subparts. They are environmental pollution from garbage, how to garbage disposal properly and garbage categories. While playing the selected game, the game will under investigation about awareness of that area of the gamer. Once the user has played the game, they can improve their knowledge, awareness of the selected area, and human abilities. The database includes the main game and all game analysis part is done. This is the overview of the AwareME awareness gaming platform.
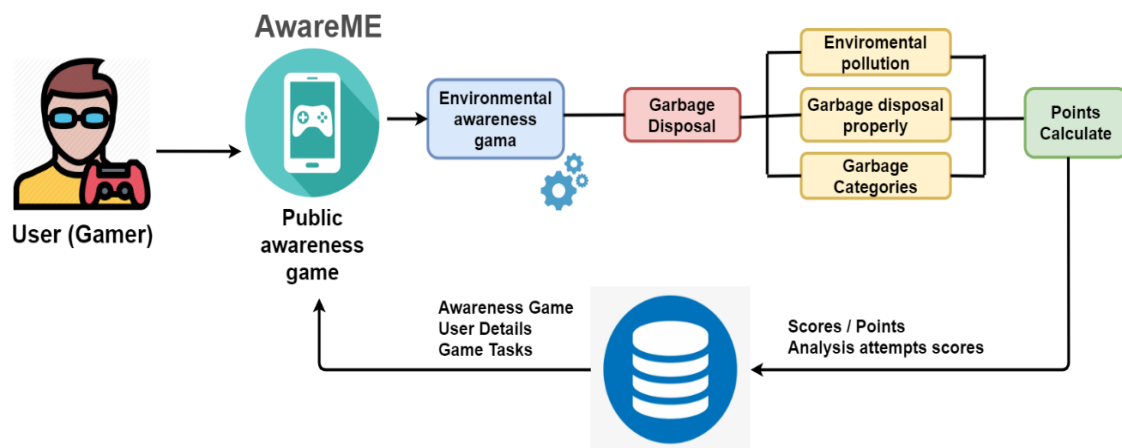
Figure 2. 2: Overview Diagram for Environmental Awareness Game

2.2 Flow of the Project

This segment discusses all steps planned for the gaming platform. In the end, every step helps to deliver a good product. This Figure 2.3 shows in detail all the steps required to create the game.
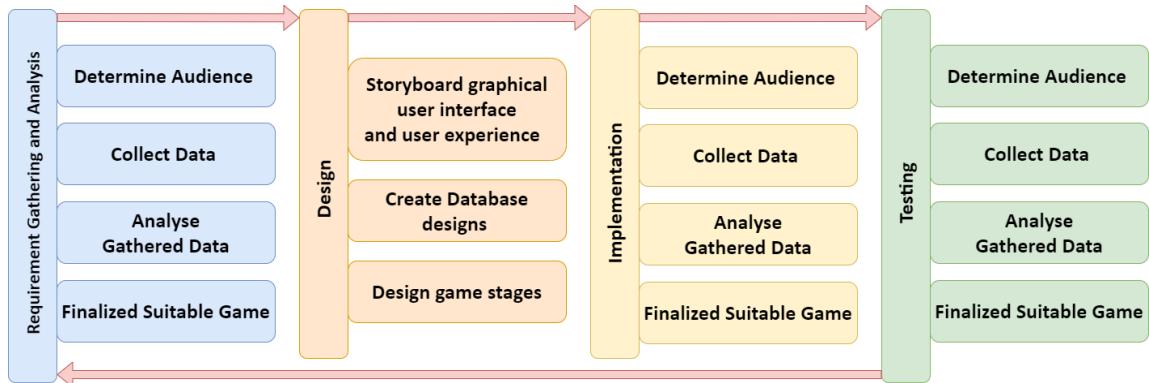
Figure 2. 3: Steps of the System

2.2.1 Requirement gathering and analysis

At the beginning of the research, the first thing that needs to be done is the process of data gathering and analysis. Analyzing and study the research area is very important to get an idea about implementation. According to this game, it needs to identify the audience to gather data. Two age groups were selected to raise awareness of proper waste disposal. This is because people of all ages in society do not dispose of garbage properly and do not know how to separate garbage.

Based on these social issues, it was decided to gather data separately from adults over twenty years of age and children under twenty years of age. After created the quiz using Google forums to collect data. The questionnaire can answer people of any age group and any educational qualification. Responses were obtained from fifty individuals.

The questionnaire consisted of sixteen questions and data were collected using these questions:

1. Enter your email
2. What is your gender?
3. What is your age group?
4. What is your highest educational qualification?
5. Rate your knowledge of garbage disposal?
6. Rate your knowledge on segregate waste?
7. How much do you know the impact of an inappropriate garbage disposal?
8. Do you know about E-waste?
9. Do you know laws and regulations related to waste management in Sri Lanka?
10. Do you know about assorted color recycle trashes?
11. What is meant by recycling?
12. What is meant by bio-degradable?
13. What is meant by degradable?
14. Select item/items that can be recycled
15. How do you dispose of household waste?
16. What do you think the most suitable game for aware people about garbage disposal?

Analyzing Google Forum's responses can lead to conclusions about respondents' knowledge of garbage. Below are some of the responses to the questionnaire.

3. What is your highest educational qualification?

50 responses
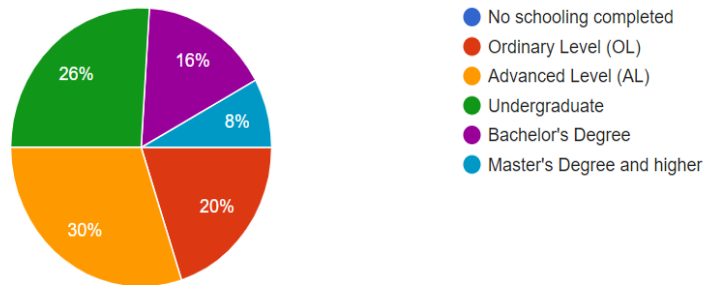
Figure 2. 4: Educational Qualification

Figure 2.4 shows people with a wide range of educational qualifications face this questionnaire. Despite the educational qualifications, one can come to a conclusion about the knowledge of the environment. Maximum Qualifications those who have completed A / L have given the highest number of responses.

5. Rate your knowledge on segregate waste?

50 responses
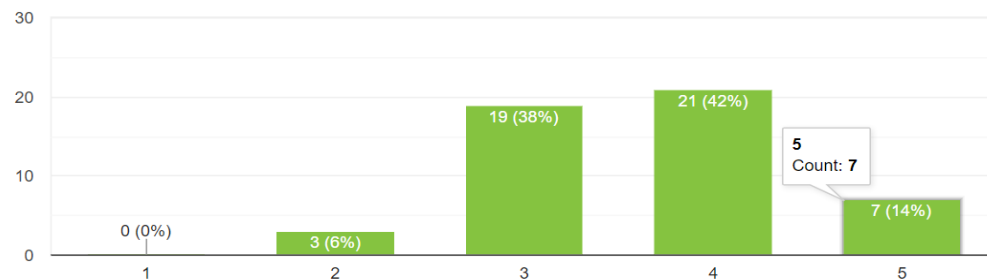
Figure 2. 5: Knowledge of segregate waste

6. How much do you know the impact of an inappropriate garbage disposal?

50 responses
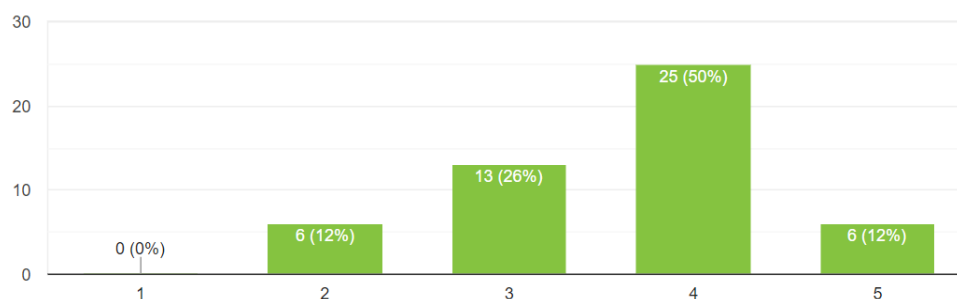
Figure 2. 6: Impact of an inappropriate garbage disposal

According to the two charts above, the rating scale shows that number 1 shows maximum knowledge and number 5 shows minimum knowledge. This figure 2.5 shows that the knowledge of waste segregation is less than fifty percent. Also, figure 2.6 shows less than fifty percent of respondents are unaware of the impact of improper waste disposal. These two figures show that people are less aware of the types of garbage and less aware of the impact of improper waste disposal.

11. What is meant by bio-degradable?

50 responses

- Process of converting waste materials into new materials and objects
- Decomposed by bacteria or other living organisms
- Susceptible to chemical breakdown
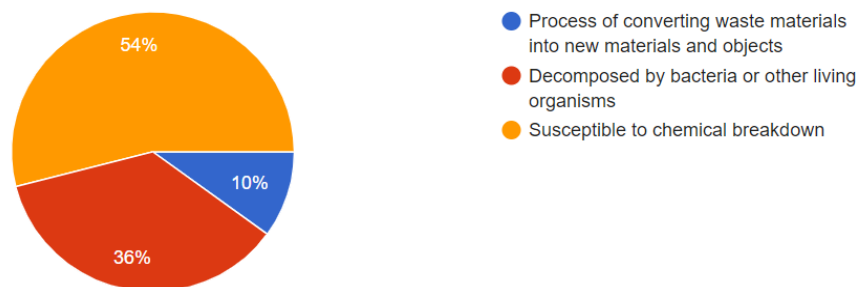
Figure 2. 7: Knowledge of bio-degradable

12. What is meant by degradable?

50 responses

- Process of converting waste materials into new materials and objects
- Decomposed by bacteria or other living organisms
- Susceptible to chemical breakdown

44%

8%

48%
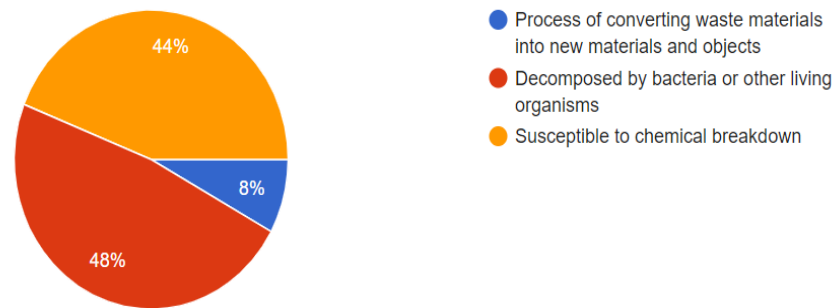
Figure 2. 8: Knowledge of degradable

There are three main types of waste decomposition. They are biodegradable, compostable, and degradable. These figure 2.7 and figure 2.8 demonstrates less than fifty percent of the two essential elements of human knowledge, waste biodegradation and degradable

14. How do you dispose of household waste?

50 responses

Burn — 29 (58%)

Throw outside — 9 (18%)

Compost — 16 (32%)

Collected by municipal — 23 (46%)
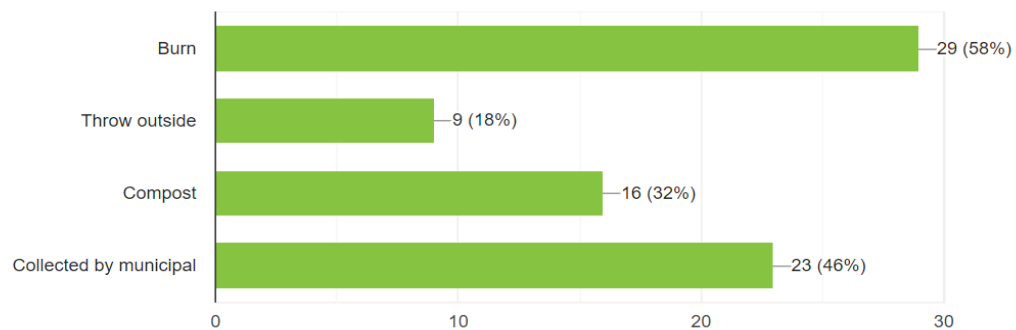
Figure 2. 9: Dispose of house hold waste

The chart above shows how to properly dispose of household waste. But most of the responses are about burning garbage. It seems that knowledge of the impact on the environment is minimal.

15. What do you think the most suitable game for aware people about garbage disposal?
50 responses
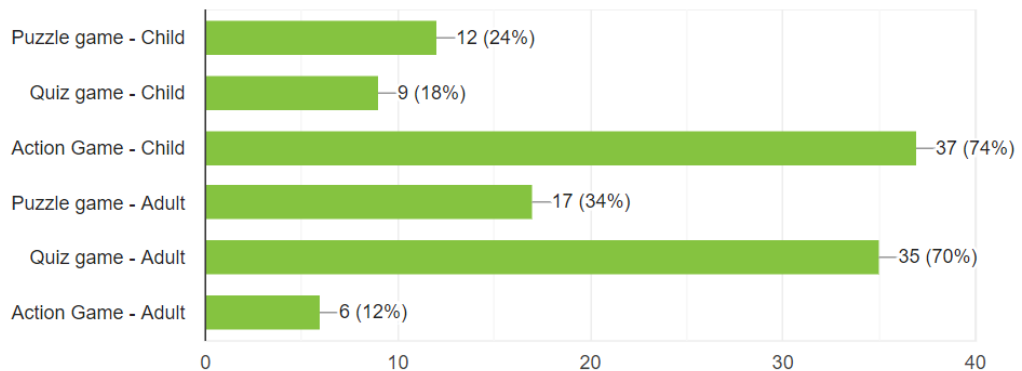
Figure 2. 10: Most suitable game

One of the questions in the quiz was "Which games are suitable for two age groups?" Responses suggest an action game for children and a quiz game for adults. Based on the responses to the questionnaire, the following conclusions were reached.

- Creating a quiz game for adults over 10 years old
- Creating an action game for kids under 10 years old
- Improving the ability to recalling through games
- Aware people about Environmental pollution, garbage disposal properly, and garbage category through the games

2.2.2 Design

At this stage, two games are designed based on the age groups. They are a quiz game for adults and an action game for children.

The quiz was designed to be created in 3 levels for the game. It was decided to include type of waste at the first level, waste disposal in the second level, and environmental pollution in the third level. Various websites, research papers, and articles were used to find information related to the waste problems required for the quiz game. In the first level, the player is given a variety of items to choose from according to their decay. In the second level, the player is given different items to choose from according to their disposal methods. At the third level, the player is asked questions about the damage caused to the environment by garbage and the existing waste disposal regulations in Sri Lanka. Scoring according to the correct answers is done at the end of the level. Quiz game is designed to improve mainly recall ability and decision making ability.

The action game was also created on three levels. At each level the player must be given items and collect recyclable materials, biodegradable materials and degradable materials. At the end of each level in this game you must also choose how to dispose of the given material. In this game, if you collect the wrong material it will reduce marks, and if you collect the correct material it will increase marks. The action game is designed to improve mainly recall ability, thinking ability and decision making ability. In this case, the two games required to raise awareness about garbage disposal have been successfully designed. Both games include waste categorizing, garbage disposal, and their impact on the environment.

2.2.3 Implementation

During this phase, the games were implemented under the requirements and design specifications of the garbage disposal. The overall project implemented using the waterfall model. 2D, 3D and virtual reality are the main technologies we used in this awareness gaming platform. Unity, Blender, Visual Studio was used as a tool for this implementation

2.2.4 Testing

One of the most important stages in the research is the testing phase. In this stage, testing is done to see how the users have improved their awareness level after playing the game. It also tests the performance of the game.

2.3 Testing & Implementation
2.3.1 Implementation

In this level that the games are created to improve awareness about waste disposal. It was decided to use 2D technology to create the quiz game and 3D technology to create the action game. Used the Unity 2019.3.8f1 version platform to implement games and the Blender platform to design 3D models. The activities of the function are implemented with C# language using visual studio 2019. The interface is designed to attract to the player and user friendly

Quiz game is a two dimensional (2D) game. The front-end design should be done first. Pictures, sounds, colors and background images were needed to create this quiz game. Some of the images were created by Photoshop and the sound was created over the internet. There are three levels implemented in this game. It shows figure 2.11. Figure 2.12 shows interface of level one.

Figure 2. 11: Levels of the 2D adult's game

Figure 2. 12: Level 1 interface 2D adult's game

Action game is a three dimensional (3D) game. The basic requirements for the front-end of the game design are 3D models and first-person actors. In this game, three steps are created and the actor can play by adding the correct items related to the level questions. This game includes learning about waste disposal and waste disposal methods. Scores are calculated correctly and levels work successfully. From level to level the game is difficult and the scoring also varies according to the level. Figure 2.13 and figure 2.14 are 3D game interfaces.
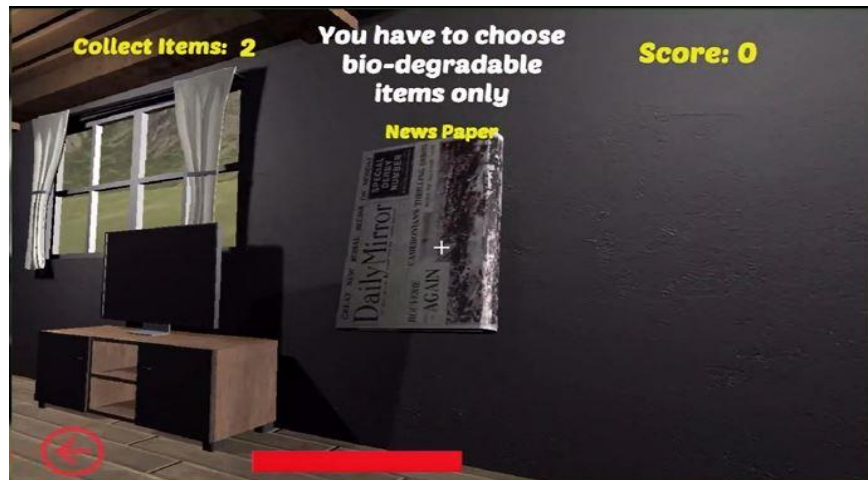
Figure 2. 13: Collect recycle items 3D children's game

Figure 2. 14: Dispose items 3D children's game

2.3.2 Testing

The main expected outcome of this research is make aware people about garbage disposal through games as well as to develop human recalling ability, decision making ability and thinking ability. Testing stage is the most important to this research.

User Acceptance Testing

After creating the game, users should be able to play the game without any problems. Each player is given two attempts and is awarded points for those attempts. All functions should be checked for functionality without any errors. If this game is not successful, repeat the format with the appropriate modifications until the desired results are obtained.

Unit Testing

Level-by-level unit testing is done here

Quiz 2D game

- Checking whether the points that are added and decreased at the level are calculated correctly
- Checking whether the questions at each level are working properly
- Checking whether the answer given is correct or incorrect
- Checking whether animations and sounds working properly

Action 3D game

- Checking whether the added and subtracted points at the level are calculated correctly during the game
- Checking to see if the material was lost when the actor got it
- Checking whether animations and sounds working properly

Component Testing

By combining all levels, component testing is performed. This component test is done to see if all the parts are working properly in individual games.

- Check to see if it is navigating correctly from level to level
- Check whether all Help functions are correctly work or not
- Check if the animations, background tones, voices, sounds are working properly

Test Cases

These test cases are used to test the game after its implementing and helps to see if the system is working properly.

Table 2. 1: Test cases for proposed system

Test Case #	Test Case Description		Test Results
1	Audio sounds	Background music	Pass
		Button sound	Pass
		Correct / Wrong sound	Pass
2	User Interface	Check Animation	Pass
		Movement background image	Pass
		Fonts (Color, Animations, Size)	Pass
		Directing buttons	Pass

3	Performance	Loading time of a game	Pass
		Animation without stuck	Pass
4	Score	Calculation of the score	Pass
		Reduce marks for wrong answers	Pass
		Score shows after finish level	Pass

2.4 Commercialization aspects of the product

Pollution is on the rise in Sri Lanka. This catastrophe caused by human ignorance affects the air, land and water in various ways. Various awareness programs have been conducted in Sri Lanka for a long time to create awareness of the impact of improper waste disposal. But garbage pollution is increasing day by day and not decreasing. The cause of this disaster is the improper disposal of garbage and the failure to educate children about environmental pollution from an early age. It is now necessary to make people of all ages aware of the harmful effects of unsuitable waste on the environment. Below are the parties who are most in need of this awareness game

- **Divisional Secretariat**

  This mobile application is mainly targeted at the Divisional Secretariat. Therefore, the Divisional Secretariat can recommend this application to the public. Therefore, the public can be easily made aware of environmental issues by conducting several public awareness programs using this mobile app

- **Awareness Sessions**

  There are a number of awareness sessions conducted by different sections for different age groups in Sri Lanka. The game can be easily popularized as the game has raised awareness on waste management.

- **Hospital**

  There are many different programs conducted by the hospitals such as awareness programs on Diseases caused by garbage. This application is very important for a hospital as it can host large groups of people at once

- **NGO**

  Now Non-governmental Organizations mostly conduct many programs for people. So, this mobile application can be used by NGO for getting for more details on people.

- **School**

  This game is also very important for school children. It is possible to conduct various sessions in the school to make aware children and hold sessions with the participation of large groups at once.
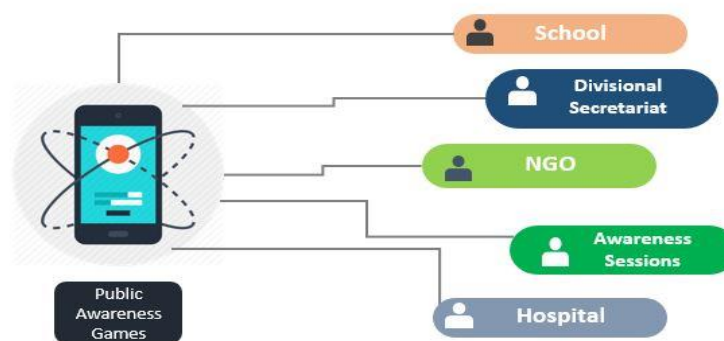

Figure 2. 15: Commercialization aspects

3 RESULTS AND DISCUSSION

3.1 Results

Gathered 50 responses from Google forums before creating the game to select abilities and identify games for age groups. Of those 50 responses, 18 children under the age of 20 and 18 adults over the age of 20 were selected to play the game. Before the game was played, a separate question paper was given to both games for the respective age groups. After that collect results of the two attempts of the games. The results obtained are as follows. Table 3.1 shows child's results of the questioner and the game and table 3.2 shows adult's results of the questioner and the game.

Table 3. 1: Children's score of the questionnaire and 3D game

Under 20 years old	Before playing the game - Questionnaire %	After playing the game - Questionnaire %	First Attrmpt - game %	Second Attempt - game %
naveenbimsara@gmail.com	20	50	40	50
udani.isuru2@gmail.com	10	40	30	60
tilandesilva123@gmail.com	30	60	40	70
ShiranSandeep@gmail.com	40	70	60	60
kasundesilva8@gmail.com	30	50	40	60
shakinibasnayaka@gmail.com	20	40	30	50
saliyaanura99@gmail.com	50	70	70	90
hasitha.damsiri@gmail.com	50	70	60	70
jayasiri375@gmail.com	50	40	50	60
kasundharmasiri@gmail.com	30	70	40	70
nimalrajasinghe@gmail.com	10	50	30	60
ramees.qwe@gmail.com	60	80	60	70
thilini.J@gmail.com	80	100	60	60
nilakshiherath97@gmail.com	60	40	70	80
Ravinduperera5@gmail.com	30	50	40	60
natasha.vonhagt@gmail.com	50	60	70	80
jagadeeshapathirana3@gmail.com	10	40	40	60
pubuduthanuja@gmail.com	20	50	50	40

20 years or older	Before playing the game - Questionnaire %	After playing the game - Questionnaire %	First Attrmpt -game %	Second Attempt - game %
ruwanthakasun@gmail.com	40	60	60	70
Dishanidep@gmail.com	50	70	60	80
neelakanthi@slsi.lk	80	100	70	90
ruwintharanga@gmail.com	50	70	60	70
arunatap@hotmail.com	60	80	50	70
dihashanuran@gmail.com	40	30	60	70
reshanwijewardana@gmail.com	30	70	50	60
pavithramoditha@gmail.com	50	70	40	60
shashikalakulathunga123@gmail.co	40	50	30	50
kalpanapiyadigamage@gmail.com	30	60	40	70
deepal.sanjaya@gmail.com	60	70	70	80
malaka9139@gmail.com	50	70	40	30
sandunv@slt.com.lk	80	90	50	70
palihadaru@slt.com.lk	40	60	50	40
manelp@slt.com	60	70	70	70
shirunipieris@gmail.com	50	60	60	70
sunilmfdo@gmail.com	70	50	50	60
Susanthakz@gmail.com	60	60	40	50

3.2 Research Findings

Below are charts of the questionnaire scores and games scores. Figure 3.1 shows a graph of the children's scores in questionnaire. Two of the eighteen children scored less after the game than before. That's about 11.11% of the total children. 88.88% seem to have gained some knowledge of garbage disposal by playing the game. Figure 3.3 shows a graph of the adult's scores in questionnaire. Compared to adults' scores, two out of eighteen scores are lower after play than before. It is about 11.11% of the total. And also one out of eighteen got same scores before and after play the game. It is about 5.55% of the total children. This charts show that more than 83.33% of the total volume has grown to some extent above the previous marks. Overall, children scored more than eighty-eight percent and adults scored more than eighty-three percent on the questionnaire.

Figure 3.2 shows a graph of the children's scores in two attempts in game and Figure 3.4 shows a graph of the adult's scores in two attempts in game. Compared to children's scores in action game, one out of eighteen scores are lower after play than before. It is about 5.55% of the total. And also one out of eighteen got same scores before and after play the game. It is about 5.55% of the total children. This charts show that more than 88.88% of the total volume has grown to some extent above the previous marks. And Compared to adult's scores in quiz game, one out of eighteen scores are lower after play than before. It is about 5.55% of the total. And also one out of eighteen got same scores before and after play the game. It is about 11.11% of the total children. This charts show that more than 83.33% of the total volume has grown to some extent above the previous marks. Overall, children scored more than eighty-eight percent and adults scored more than eighty-three percent on the questionnaire.

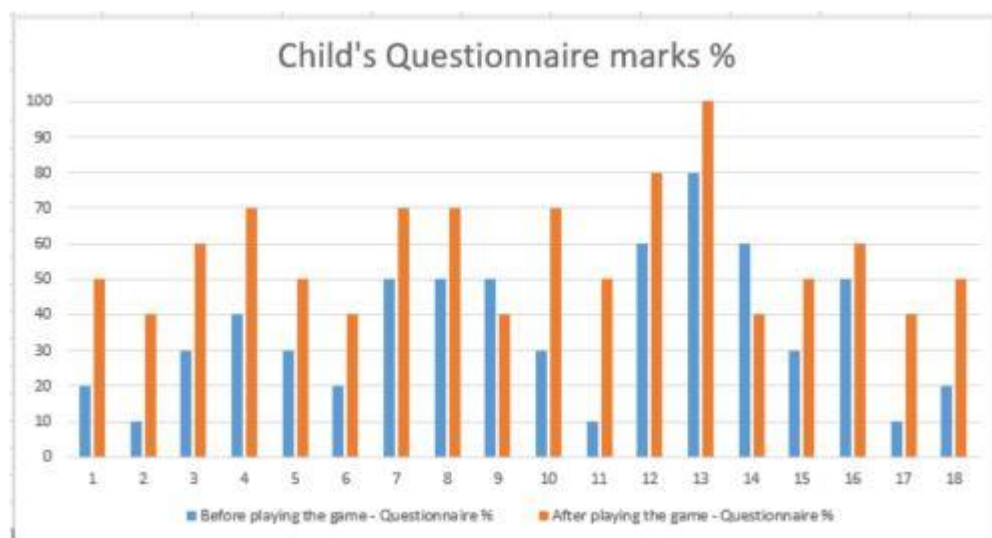- **Children's scores of the questionnaire and two attempts of 2D game**

Figure 3. 1: Graph of the questionnaire score with two attempts – Children's game
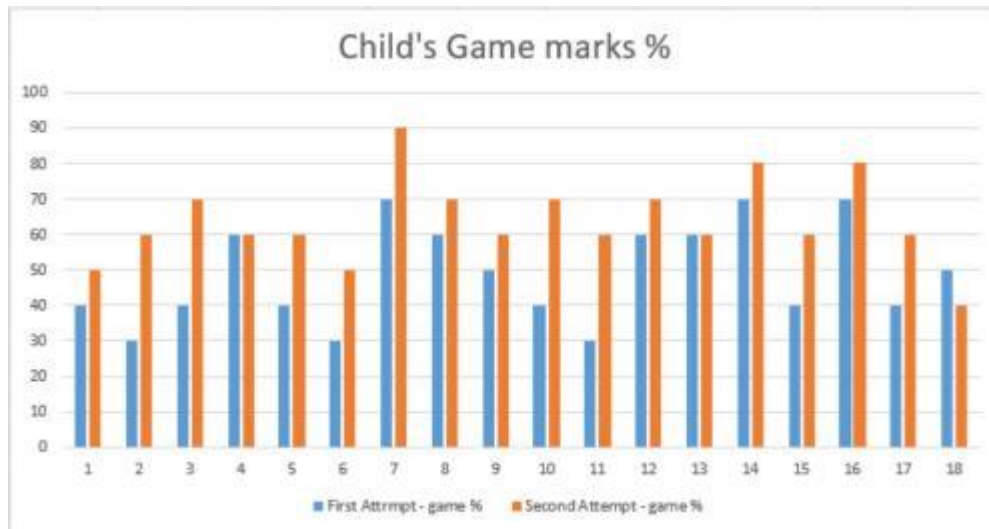
Figure 3. 2: Graph of the game score with two attempts - Children's game

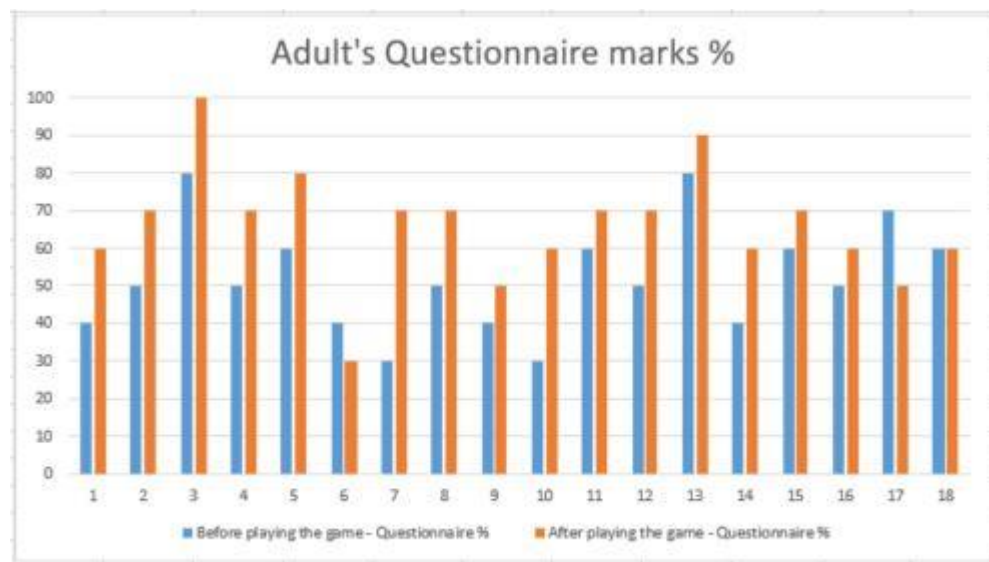- **Adult's scores of the questionnaire and two attempts of 3D game**

Figure 3. 3: Graph of the questionnaire score with two attempts – Adult's game
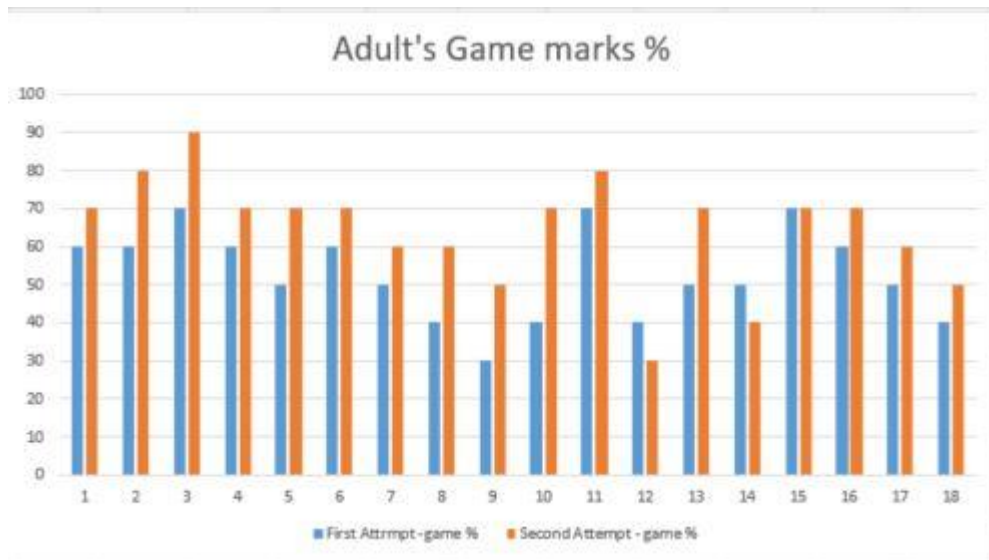
Figure 3. 4: Graph of the game score with two attempts - Adult's game

3.3 Discussion

In this case, several conclusions can be drawn from the data collected from a test conducted in a questionnaire and games using 18 adults and 18 children. From level by level the game is difficult and the scoring also varies according to the level.

In the questionnaire, eighty-eight percent (88%) of children's scores are higher than those of later scores. Also, the score obtained after eleven percent (11%) is less than the score obtained earlier. In the game also, eighty-eight percent (88%) of children's scores are higher than those of later scores. Also, the score obtained after eleven percent (11%) is less than the score obtained earlier. It is concluded that more than eighty percent (80%) of all children have developed knowledge through this awareness game.

In the questionnaire, eighty-eight percent (83%) of adult's scores are higher than those of later scores. Also, the score obtained after eleven percent (16%) is less than the score obtained earlier. In the game also Eighty-three percent (83%) of adults' scores are higher than previous scores. Also, the score obtained later is less than the score obtained sixteen

percent (16%) earlier. Here again, it is clear that more than eighty percent (80%) of all children have developed knowledge through this awareness game.

Overall, it seems that more than 80% of children and adults are aware of garbage disposal. And also, overall scores on the games show that children's recall ability, thinking ability, and decision-making ability is enhanced by playing the children action game, and recall ability and decision-making ability is enhanced by playing the adult quiz game.

4 CONCLUSION

Garbage pollution is one of the most pervasive social and environmental problems in Sri Lanka. Due to human negligence, proper waste disposal causes great harm to the environment. The damage to the environment is done by people of all ages. The main reason for this problem is that people are not aware of garbage disposal properly. The main reason for this study is to reduce the pollution caused by garbage in Sri Lanka and to create a garbage-free country. As modern society is passionate about games, it was decided to use game-based learning to raise awareness about garbage disposal and environmental damage.

Created a quiz using Google forums and gave it to fifty people of all ages to fill out to test their level of knowledge. From the responses, we came to several conclusions. They are, developing two separate games for adults over 20 years and children under 20 years old. Creating a quiz game for adults and an active game for children. Developing human recall ability through games.

After that, it was decided to create at the design level Quiz Game 2D technology for adults and Game 3D technology for children. Unity platform (2019.3.8f1 (64-bit)) was mainly used to develop the games. First, we designed a 2D Quiz game and 3D action game before the implementation. It was decided how all the levels in both games should be designed, how to score and what it should look like. 2D, 3D, Virtual reality were used as technologies, and Blender, Photoshop were used as tools for both games. After creating the games, each game was tested. Each game was taken separately and tested on different parts of the game. After testing all the parts of the game, redesigned them to solve its problems.

Then 18 adults and 18 children were selected and given a pre-game quiz and after the game the same quiz was given and the scores were compared. The game allowed them to play twice and the scores were compared. This worked for both types of games. The points

scored using the quiz and the points scored by the game twice were used to demonstrate the success of the game. In both cases the score is more than eighty percent successful product. In addition, this game can be improved step by step considering the feedback from people.

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APPENDICES

Appendix A: Usecase Diagram

Awareness Game Platform
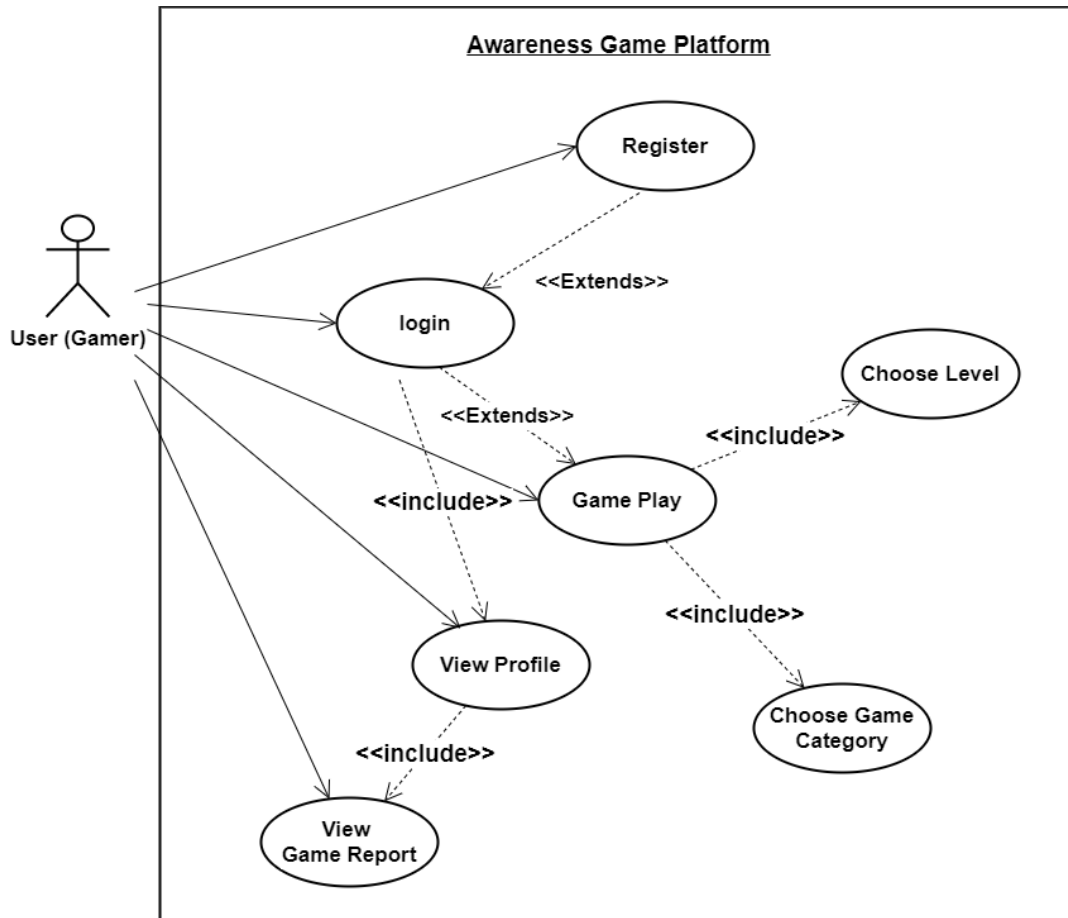
Appendix B: Work Breakdown Chart
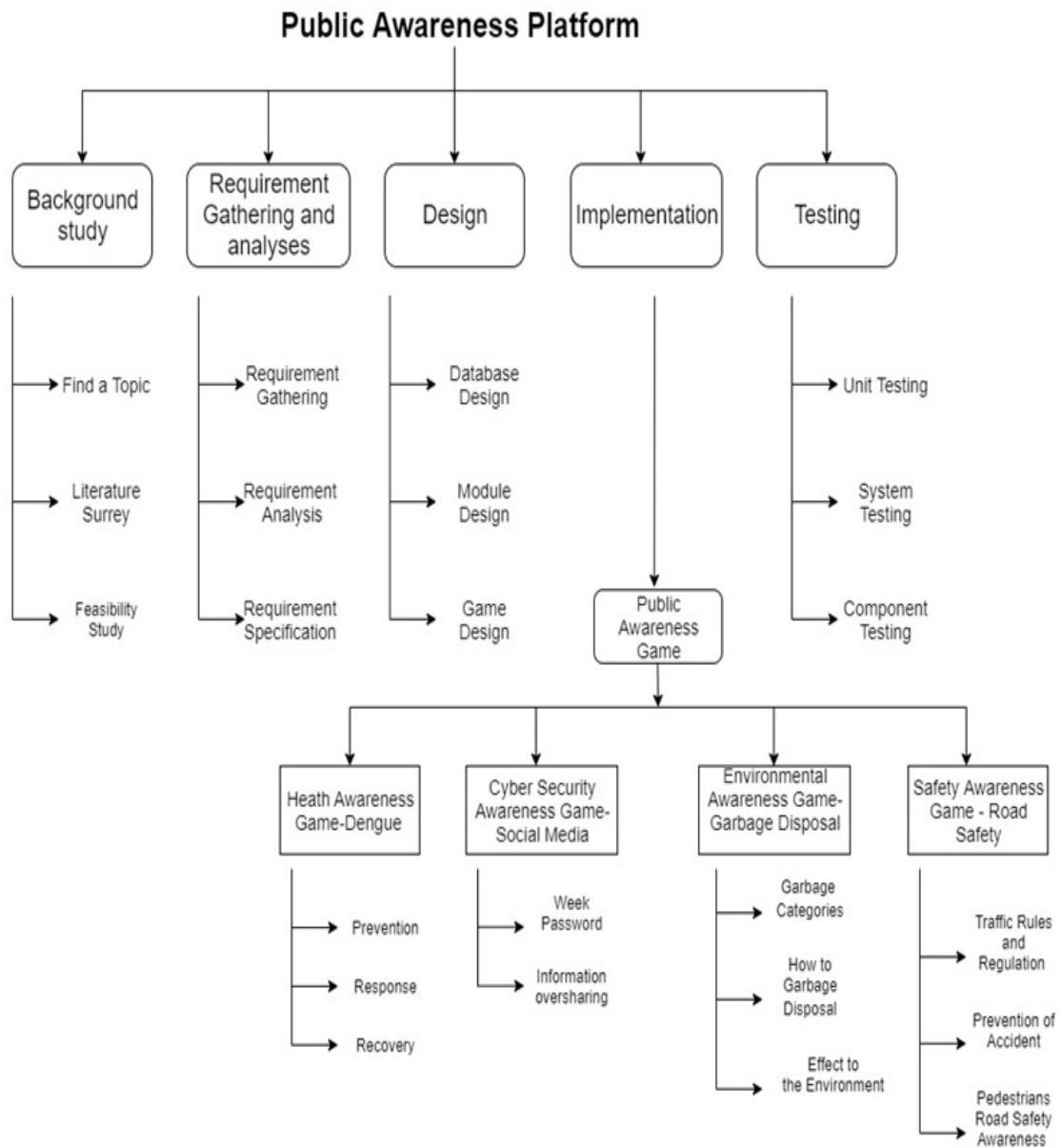
Appendix C: Data Collection Google Forum

A study on "Garbage Disposal awareness through game-based learning"

A short survey to identify the depth of knowledge on the garbage disposal and identify the ability which needs to be increased proper garbage disposal.

This survey is a part of research to be completed as partial fulfillment of the requirements for the degree of bachelor Information Technology | Sri Lanka Institute of Information Technology (SLIIT)

Enter your email *

Short answer text

1. What is your gender? *

○ Male

○ Female

2. What is your age group *

○ Under 20 years old

Appendix D: Adult's Questionnaire

A study on "Garbage Disposal awareness through game-based learning" - Questionnaire for Adult's

This survey is a part of research to be completed as partial fulfillment of the requirements for the degree of bachelor Information Technology | Sri Lanka Institute of Information Technology (SLIIT)

Enter your Email

Your answer

1. What is meant by biodegradable?

○ Process of converting waste materials into new materials and objects

○ Decomposed by bacteria or other living organisms

○ Susceptible to chemical breakdown

2. What is meant by degradable?

○ Process of converting waste materials into new materials and objects

○ Decomposed by bacteria or other living organisms

○ Susceptible to chemical breakdown

Appendix E: Kid's Questionnaire

A study on "Garbage Disposal awareness through game-based learning" - Questionnaire for Kid's

This survey is a part of research to be completed as partial fulfillment of the requirements for the degree of bachelor Information Technology | Sri Lanka Institute of Information Technology (SLIIT)

Enter your Email

Your answer

Select degradable items

☐ Plastic

☐ Meat

☐ Cloths

☐ Glass

☐ Metal

Select bio-degradable items

☐ Bones

☐ Paper