



Germ Hunter – Mobile Game with Educational Content

**A dissertation submitted for the Degree of Master of
Information Technology**

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Declaration

The thesis is my original work and has not been submitted previously for a degree at this or any other university/institute.

To the best of my knowledge it does not contain any material published or written by another person, except as acknowledged in the text.

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Abstract

Mobile games addiction is considerably affected for educational activities of youngsters age group within 10 -12. Comparably less mobile games are available with educational content despite many mobile games are focusing only on entertain the players. Educational applications are generally less effective because of the inability to keep player attach to the game while improving creativity and knowledge. Introducing new mobile technology platform with educational content can be inspired youngsters to engage and learn. But the application needed to be joyful stabilization of knowledge, challenging and practical using the gamification approach rather than presenting only a learning tool.

This project work presents one such approach that uses game-based learning concept which is an infinite runner mobile game. Player character move along with the floor plane. All other gameplay related background assets save as prefabs and generate infinitely along with player's running direction. Characters behave under the Unity state machine base on the user's touch input. Modeling applications are used to create 3D game assets and the internal human organs. Scripts are attached to most of the gameplay objects to control their behavior. The players are allowed to get knowledge of human anatomy with the help of Augmented Reality which is an interactive experience of a real-world environment.

Perfomance and effectiveness of the proposed analysis verify by comparing result of the selected players' feedback. This concept can be tailored to other large theoretical and complex educational content as well.

Keywords: educational games, game-based learning, augmented reality, mobile, infinite runner

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List of Abbreviations

AR - Augmented Reality

3D - Three Dimension

GUI - Graphical User Interface

API - Application Programming Interface

HUD - Heads Up Display

AI - Artificial Intelligence

VR - Virtual Reality

PC - Personal Computer

1 Introduction

1.1 Background

There are comparably less mobile applications available with educational content despite many of the mobile games are focusing only on entertaining the young generation. When it comes to applications with educational content, most of them are not presented in an attractive way to youngsters. That was lead them addicted to mobile games.

Fun and interactive activities that are useful to help increase the attention span of the child. The most important aspect of these activities is to attract the interest of the child first. Susan Pitman, Senior Research has indicated that children's learning process is accelerated by video games, academic content and problem-solving. It will also be helpful for children with learning problems [1].

The potential of combining smartphones and Augmented Reality (AR) for education is high. It could grant students extra digital information about any subject and make complex information easier to understand.

The project consists of designing and developing a Mobile Game for youngsters. The gameplay based on educational content. By scanning printed targets, the application is shown 3D models of internal human organs using AR technology.

1.2 The Motivation

Endless runner mobile games had been becoming very popularize among people recently. Temple Run is the best example for mobile infinite runner games, the endless running type of game is an extremely simplistic spin on the larger “platform” genre where a player has limited control over a character that is constantly moving forward [2]. Running games are usually very enjoyable and less stressful [3].

AR is one of the most rising tech topics in recent days. It is an interactive experience of a real-world environment whereby the objects that reside in the real-world are "augmented" by computer-generated perceptual information [4]. In teaching, the use of virtual and augmented reality has been on the rise, exploring different means of interaction and student engagement. It is adopted in educational projects to mediate an enhanced visual and cognitive perception. Recently it is used also for the creation of AR games.

Educational games are modern learning and training strategies for engaging learners and stimulate active learning through a game-like scenario. They are games that are designed to help people to learn about certain subjects, expand concepts.

Most of the existing educational games were mainly focused on the content, less entertaining factor.

Combining endless runner game platform and Augmented Reality technology with some educational content makes the player to easily identify, understand and remember the particular content without an effort while entertaining the game.

1.3 Problem Addressed

Being accustomed to digital technology, children have changed considerably their ways of thinking and processing information based on different mindsets from their parents. For most children, computer games have become a major part of their lives and become the most common activity in children's leisure time.

Game-based learning is becoming popular in the academic discussion of Learning Technologies. However, even though the educational potential of games has been thoroughly discussed in modern days, learning became difficult due to the short attention spans of them. In addition to traditional methods of learning and teaching, such as reading books and newspapers.

This application focuses on how to support the education of children to accelerate learning, remembering and communication through effective and interactive learning for children with the help of modern technology.

Designing the core concept of the game is the most important thing in development. The application uses attractive gameplay and the latest technologies to get interested in youngsters. Because the most important aspect of these activities is to get the interest of the player first. Then it is easy to give them some educational content through the application.

1.4 Aims and Objectives

Implementing an educational mobile game was the main aim of this project. In modern society video games have been becoming a major role. It is highly valued for entertainment than educational purposes. The attempt was added educational value to this game addiction in an attractive manner rather than presenting only a learning tool. This contribution included analyzing, design, development, and evaluation of a game-based learning concept which is based on mobile devices. The game is focused a joyful stabilization of knowledge and the engagement of players using the Gamification approach and its game mechanics.

The likeness of experiencing new technology of young people was identified as a key benefit when analyzing the above domain. AR was selected as a potential technology to keep the player engage and motivate. The application was included human internal organs as AR content. The objective is to motivate students for learning complex and difficult theoretical content.

Designing game esthetics and assets by highlighting gameplay, developing a game concept in an attractive and efficient manner were objectives of the project. Game Design Document was prepared and game prototype version was developed prior to the main design and implementation of the project. It was helped to reduce issues in further development.

Furthermore, the application collects player details to display player performance - maintain leader board for improving game quality, monitoring and assessment of player behavior. Results indicate increases in player motivation, engagement, satisfaction, and retention and performance enhancement.

1.5 Project Scope

The proposed mobile game is ensured to implement its gameplay concept with providing educational value. Primary Gameplay idea is blood cell running through the vein fighting with germs and avoiding barriers. GDD has described more on the gameplay concept – Appendix A, page 56.

In order to access the full functionality of the game, the user has to register with the application. After login to the system user able to access full components. When the game is over user score have to send to the server. Based on the score gain through the game, AR components will be enabled. User can see the internal human organ with the help of AR technology. User has to use the app icon as an image target to view the organs. The tutorial questioner is enabled based on the 3D models that user able to view in AR components. That question is prepared to evaluate players' knowledge regarding the human internal organs. The tutorial score also sends to the server separately.

A game leader board will display players' performance. Sounds and language, the setting can be done using Settings Screen.

1.6 Evaluation Process of a player performance

- Maintain the player detail (login and registration)
- Maintain database for recording player performance.
- Use analytics dashboards - Analyze the performance of each player.
- Stores the current level, the current score and a handful of other stats like Super Mario Galaxy and earlier console module based games. These save games generally require very little memory.

1.7 The novelty of the Approach

Most of the similar projects focus mainly on the content. It is very important to have entertaining factors to get the interest of the players. This endless runner game will embed augmented reality technology, which will present a novel experience to the player.

1.8 Outline of the thesis

The literature review and the necessary information related to the project is presented in the next chapter. It contains Augmented Reality techniques and video games with educational content.

Chapter 3 describe the methodologies applied in the project and why those techniques used. It includes the justification of the selected approaches with alternative solutions. Critical analysis of the problem under investigation is given in this chapter.

Chapter 4 describes the implementation details of the proposed hypothesis with sample code segments. This chapter presents how game architecture and design be developed.

Chapter 5 is followed by the 'Results and Evaluation' section. 'Results and Evaluation' section will specify the results obtained and how player performance be evaluated through conducting this project. Those results will be evaluated to arrive at appropriate conclusions.

The final chapter of this report will summarize the work that has been carried out for this project and will discuss possible future enhancements for the proposed approach.

2 Literature Review

Computers and mobile phones play a major role in shaping the future of children. Days are gone when children loved to indulge in outdoor activities. Computer games and video games have become very popular in children and adolescents' life and play a prominent role in the culture of young people [5]. Taking into consideration, games are positively a great mind exercise and helps kids explore many new things. It includes improvement in recursive and proactive thinking, interpretive skills. Game-based learning allows the student to learn, large or complex educational content without any effort through the repetition. According to Molcho (1988) [6] - The Research on Gaming, gaming has provided evidence that can promote retention and the ability to transfer knowledge to new domains.

Providing fun activities that allow the child to focus on for a long period of time, it is important to increase the attention span of a child. [7] Fun activities that are useful to help increase the attention span of the child. The most important aspect of these activities is to get the interest of the child first. The learning process is accelerated by children video games related information, academic content and problem-solving. It will also be useful for children who suffer from learning problems [8].

2.1 Effect of Computer-Based Video Games on Children

Over the last decade, educational games have become more and more popular. There are many games specifically designed as educational games, as well as a number of entertainment games that have been successfully used for educational purposes [9].

The use of multimedia in education has significantly changed people's learning processes. Results from a number of research studies indicate that appropriately designed multimedia instruction enhances students' learning performance in science, mathematics, and literacy [10]. Previous studies indicate that computer-assisted instruction (CAI) programs have important factors that can motivate, challenge, increase curiosity and control, and promote fantasy in children [11]. Despite the fact that computer and video games have the same multimedia capability as CAI programs, their potential learning impact is often discounted by parents and educators. Recently, computer-based video games' presence and popularity have been ever-growing, and game developers and researchers have started to investigate video games' impact on students' cognitive learning [12].

2.2 Augmented Reality in Educational Games

Augmented reality (AR) has been shown to have good potential in making the learning process more active, effective and meaningful. This is because its advanced technology enables users to interact with virtual and real-time applications and brings natural experiences to the user. In addition, the merging of AR with education has recently attracted research attention because of its ability to allow students to be immersed in realistic experiences [13].

The potential of combining smartphones and Augmented Reality for education is high, though it still has to be fully discovered. AR, in various ways, could grant students extra digital information about any subject, and make complex information easier to understand. Augmented reality in education will soon affect the conventional learning process [14].

2.3 Player Performance Analysis

Gameplay data in serious - educational games may be turned into valuable analytics or actionable intelligence for performance measurement, assessment, and improvement.

It is important to know what play-learners have done in the game environment, and if the performance of the actions brings about learning? Could they be playing the game for fun, really learning with evidence of performance improvement, or simply gaming the system, i.e., finding loopholes to fake that they are making progress? [15]. Learning analytics provides new opportunities for supporting the progress of educational games.

2.4 Game Genres, Learning Techniques, and Learning Styles

Game genres can be categorized as Action, Adventure, Fighting, Puzzle, Role-Playing, Simulation, Sports, Strategy, etc. Different game genres have a different impact on the content of learning activities [16]. Some contents are best learned through role-playing and adventure games, others are best through game show competition, action, and even sports games [17]. Different games appeal to different people. Choosing the appropriate type depends on the content to be learned and or mentally processed to be developed.

Knowing children's learning style and finding appropriate ways to create or enhance a learning environment such as choosing an appropriate game type for each style of learners will increase the student's learning success.

2.4.1 Prensky's Study: Learning Techniques and Learning Activities Used in Educational Computer Games

Prensky[18] discusses how to combine gameplay and learning. Prensky proposes the relationship of learning content, learning activities and possible game style as shown below in Fig 2.1.

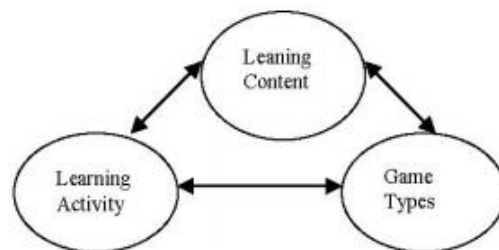


Figure 2.1: Model of the relationship of learning content, learning activities and possible game styles

2.4.2 The Study of Chong et al.: Learning Styles and Educational Game

Many educational researchers studied learning styles, but the study on the relationship of learning styles to learning within the game text is scarcely found. Researchers are emphasizing that education computer games should be developed considering the learning styles of students [19]. However, there is research conducted by Chong et al. on the impact of learning styles on the effectiveness of digital games in education.

The application (Germ Hunter) is an endless runner game with s educational content. The educational computer game has many similar characteristics like any other genres of games. However its particular aspect is designed to teach, and in which the main objective involves in learning a topic. To develop an effective educational computer game, earning activities and techniques, and learning styles are important issues for consideration. [20] [21].

2.4.3 Endless Game Genre

An endless game is a concept in which the player is theoretically able to score points infinitely. The objective is to achieve as many points as possible by repeatedly interact against the game over trigger [22]. The crucial feature here is that the difficulty of the game progressively is increased in a short period of time. The smartphones touch screen has simplified the controls for mobile games [19]. Iconic endless games that have gained popularity are Temple Run, Doodle Jump or Flappy Bird.

2.5 Existence of similar systems

2.5.1 Project Remedium

It's a game where you play as nanobot and you are inserted into the human body to fight bacteria and other kind of creatures. It is story driven shooter blends realism and actual medical facts with both metaphorical approaches to healing and dynamic, combat-packed action. [23]

2.5.2 The Body VR: Journey inside a Cell

The Body VR: Journey Inside a Cell is an educational virtual reality experience that takes the user inside the human body. Travel through the bloodstream and discover how blood cells work to spread oxygen throughout the body. Enter one of the billions of living cells inside our body and learn how the organelles work together to fight deadly viruses.[24].

2.5.3 MicroBot

The game is a twin-stick shooter that takes place within a human body.

Gameplay: Fictional medical corporation MicroHexon has developed a line of microscopic robots designed to fight infection inside humans. The player controls a fourth-generation MicroBot, the newest iteration of the series. It is tasked with destroying infections caused by now-corrupted previous generation MicroBots.

Some excellent examples of augmented reality in education usage worldwide are listed below

2.5.4 Human Anatomy Atlas

Human Anatomy Atlas by Visible Body is a great tool to teach students about the human body, including major organ systems, the skeletal structure, and muscle composition [25].

This app goes in-depth with 3D models of the human body that students can interact with to learn their functions. Visible Body also includes a 1,000+ question quiz bank, multiple language settings, and descriptions of injuries and diseases, which can aid instructor lesson planning.

2.5.5 Anatomy 4D

Best suitable for medical students' needs. By scanning printed targets application shows a 3D model of the human body and allows to interact with it. Users may customize any part of the human body [26], look at how parts fit, how different are joint moves and how human organs function.

2.5.6 Human Heart 3D

Another AR anatomy application with much shorter content base, but much deeper. Students may explore the human heart in details. 3D model of heart completed with animation to view how it works, using the support of text tips with explanations about the heart's functionality and anatomy [27].

2.6 Critical Analysis of the Similar Systems

In the above section, 2.5 have been described the similar applications and their features. Pros and cons of the similar system were identified, compared over the features were proposed in the project "Germ Hunter". Human Anatomy Atlas, Anatomy 4D, and Human Heart 3D are focused mainly on high school and higher education students due to the required technical skill and general health knowledge. Although those support for multiple platforms not freely available for the users. And no gamification approach only educational content with AR.

Project Remedium is Story-Driven Action Shooter, Adventure, Indie game only available for the PC platform. It is included high-end graphics, interactive environment with simulating internal processes like bloodstream. But it was not focused on educational value.

The Body VR: Journey inside a Cell, educational virtual reality experience that takes the user inside a human cell. It is available on Samsung Gear VR, vive and Oculus. The body VR is clearly focused on educational content by giving the user to exploratory experience.

MicroBot is Dual-Joystick Shooter in Sci-Fi theme available on Xbox 360 Games Store and PlayStation Network (PS3) platforms. MicroBot is focused attractive gameplay story including randomly generated levels, reward systems, and power-ups. Summary of critical analysis of the similar systems is given in Table 2.1.

Table 2.1: Summary of critical analysis of a similar system

Features	Project Remedium	The Body VR	MicroBot	Human Anatomy Atlas	Anatomy 4D	Human Heart 3D
Target Audience	Common	Common	Common	higher education students	higher education students	higher education students
Available Platforms	PC	Samsung Gear VR, vive and oculus	Xbox 360 Games Store and PlayStation Network (PS3)	Android/iOS/Windows	iOS	Android/iOS
Free/Paid	Free	Free	Free	Paid	Paid	Paid
Educational Value	Included some educational value to the gameplay	the award-winning educational VR experience	Included some educational value to the gameplay	Yes	Yes	Yes
Game Play Story	story driven shooter	Explorative	Sci-Fi	No	No	No
Genre	Story-Driven Action Shooter, Adventure, Indie	Educational, Exploration, Narrative	Dual-Joystick Shooter	Educational	Educational	Educational
Graphics	High-end/3D/2D	High-end/3D/2D	High-end/3D/2D	High-end/3D	High-end/3D	High-end/3D

2.7 Summary

All similar project were described above, have unique features for each. But considering facts that a project was achieved, The Body VR had been given a brilliant solution. It was included educational content in an explorative way which was held player's curiosity continuously.

3 Analysis and Design

Game is a kind of software with the goal to provide entertainment. During the real game development practice, simply adopting the software development life cycle (SDLC) is not enough, as the developers face several challenges during its life cycle. To address the problem, game development uses a kind of specific approach called game development life cycle (GDLC) to direct the game development [28]. The Proposed GDLC model is shown in fig.1[28]. It consists of 6 development phases. Production cycle consists of Pre-production, Production, and Testing.

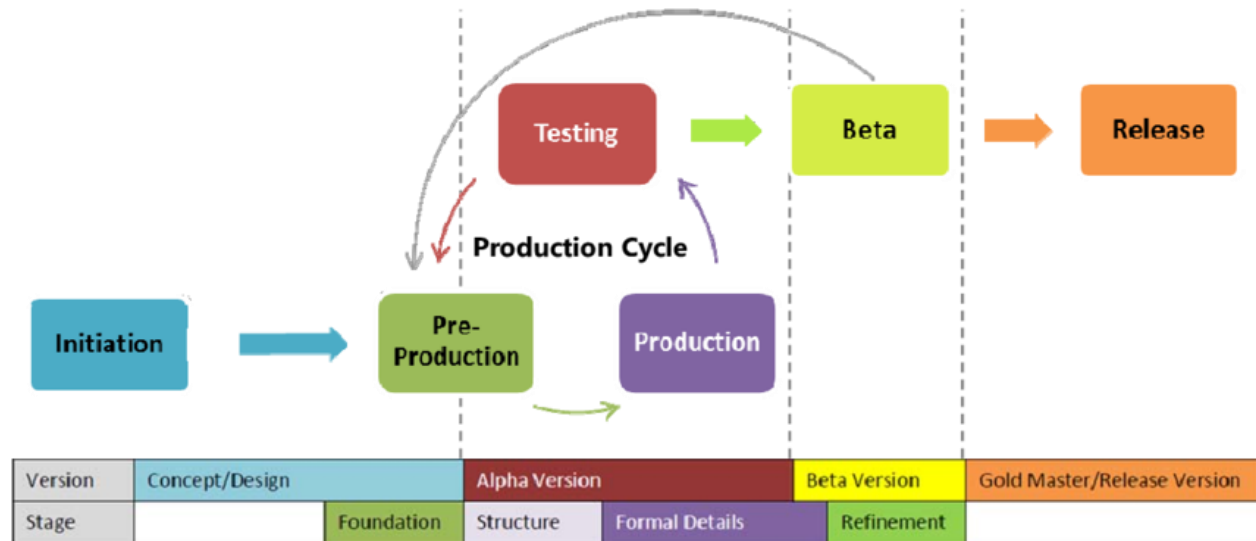


Figure 3.1: GDLC Model

From the comparison between GDLCs’ activities and SDLC’s activities, the most prominent difference between SDLC and GDLC is the assets management during game design and production phase. In game development, the software part of the project is not the only one, and it must be considered in connection to all other parts: The environment of the game, the story, characters, game plays, the artwork and so on.

Initiation

The first step done in creating a game is to create a rough concept of what kind of game that will be created.

Pre-production

Pre-production is one of the first and foremost phases in the production cycle. Pre-production involves the creation and the revision of game design and the creation of a game prototype. The game design focuses on defining the game genre, gameplay, mechanics, storyline, characters, challenges, fun factors and technical aspects. Form of the prototype is made to assess the game

design and the whole idea. In the first iteration of the production cycle, the created prototypes are foundations and structure, while in the next iterations, the related prototypes to be refined are formal details and refinement.

Production

Production is the core process which revolves around the assets creation, source codes creation, and the integration of both elements. The related prototypes in these phases are formal details and refinement.

Testing

Testing in this context means internal testing conducted to test the game usability and playability.

The testing method is specific to each prototype stage.

Beta

Beta is a phase to conduct third-party or external tester called beta testing. Beta testing still using the same testing methods as the previous testing method, since the related prototypes in the beta testing are both formal details and refinement.

Release

The game build has reached the final stage and ready to be released to the public. Release involves product launching, project documentation, knowledge sharing, post-mortems, and planning for maintenance and game expansion.

This chapter describes the conceiving the idea of what kind of game it is going to be, and how it should apply with regard to the analysis and design.

3.1 System Initiation

3.1.1 Planning

This phase includes planning of game user interfaces, levels, characters, and related assets design. As the first step of the planning, Game Design Document (GDD) was prepared. A game design document is a blueprint from which a game is to be built. GDD was started to write after a high-level concept is finalized. GDD can be found in Appendix A.

Germ Hunter Prototype was developed while preparing the GDD. The game high-level concept contains more high-end graphics content. Therefore it needs to be tested before starting work on final assets design. The main intention of creating a game prototype version is how would affects the high-end graphics for game performance on a mobile platform. Also wanted to know what the final output was like.

Game Concept

Germ Hunter is a mobile game which will be implemented in Unity game engine. It is an endless runner with a finite amount of premade levels, thus the term finite runner. Player has to play the role of a Blood Cell which is running through the vein. The gameplay consists of collecting different varieties of power boosters, avoiding obstacles and hostile creatures all the while running through the fantasy world. Blood cell has to fight with the germs. Germs also can attack the blood cell. Both germ and blood cell lose energy/health when fighting. When the player completed a particular level can get an augmented reality experience - by viewing internal organs of the human body. Each player details and the performance will be shown as a dashboard.

Game design and gameplay will be supposed to become an educational value added one as well as joyful. Because the game should be enjoyable to make it popularize among the kids. Some of the processes inside the human body will be embedded as game challenges in a joyful manner. As a technology Augmented Reality will be used for a small part of the application.

Title - Germ Hunter: Runner mobile game embedded AR feature.

Player Motivation - Randomly generated obstacle, pickup, and enemies make gameplay interesting

Player Role - Blood Cell

Genre - Action, Educational

Target Generation - Youngsters

Unique selling point - Runner mobile game embedded AR feature.

Target Hardware - Android Devices

Germ Hunter Prototype Design

Dummy characters and assets were used for developing a game prototype. It used the same platform and background repeating effect instead of the platform follows the player. Three types of enemy characters were spawned from the different spawn point, and the AI component sets their target as the player character. The player can shoot and harm the enemies as well as enemies can do the same. Every character has own predefine health. When health becomes zero characters will die and sink through the floor.

Player character does its action based on the user's input. The player can jump/slide when the user swipes the screen up/down. Player moves left and right base on the device accelerometer input. Modern mobile devices have a built-in accelerometer which allows them to know their orientation in 3D space. Prototype version uses devices orientation to control the player character's horizontal movements.



Figure 3.2: Germ Hunter Prototype Version

Performance of the prototype game on the mobile devices slows down when playing continuously. As a conclusion, it's better to minimize the use of 3D assets, use 2D game art instead of 3D background assets and use low polygon models.

Based on the result and experience gain through the prototype version, some aspect of the game is revised.

3.1.2 Analysis

Requirements for gameplay design was analyzed and described during this phase.

Functional Requirements

Functional requirements describe what the application should do.

- Player should have ability to register, login and play the game.
- Highest score of the relevant player must be display at beginning of the game.
- Player should have ability to see internal human organs when he/ she enable the AR level by using app icon as a image target.
- Player should be able to start a new game at anytime and quit a game at anytime.
- Game should automatically speedup player's running speed.
- Ability to load leaderboard.
- Application should have proper navigation system.
- In a tutorial level the player should able to quit anytime and game should display earned marks at end of the each question.
- Player should able to mute sounds and change the main screnn's language.

Non- Functional Requirements

Functional requirements describe the application behaviours.

- The application must have attractive user interface.
- The application must not lag or freeze.
- Child safe colors must be use in throughout the application.
- Application should not have loading time more than 15 seconds.
- Minimum frame rate must be twenty frames per second.

Software Requirements

Software needed in designing & implementing the system

- Unity [29].
- Autodesk Maya 2014: 3D Modeling [30]
- Adobe Photoshop and Illustrator
- Android Software Development Kit (Android ADK): Software development kit for applications on the Android platform.
- Visual Studio
- SQL Server Management Studio

Hardware Requirements

- Desktop Pc/ Laptop
- Android Mobile Phone

User Hardware and Software Requirements

- Android Mobile Phone

3.1.3 Feasibility Study

The feasibility study helps to freeze the requirements, the scope, portability and other conclusions of the proposed game. The prototype version of the game came to conclusion use of 2D game art instead of using 3D assets. When considering creating 2D game art, it is not technically feasible. Because of that, need to reconsider some of the gameplay concepts. Non-

expert with the certain designing platform also not technically feasible. (Eg: Developer is not an expert with Adobe Illustrator)

Analyzed and listed down all functionalities and the requirements (Shown in fig.2) of the germ hunter to identify those technical and other issues.

<p>Main Function</p> <ul style="list-style-type: none"> - Login - Register - Show Player performance analytics - Leaderboard - Show internal organ using AR tech when player win particular level - Saving the state of the game 	<ul style="list-style-type: none"> - Jumping - Stop running when there is barriers and break it - Attacking to germs - Attacking to blood clots - Get the power by collecting power boosters - Reduce the health when get attacked - Die wen health is zero
<p>Common Function</p> <ul style="list-style-type: none"> - Score system - Player and Enemy health - Running distance - Game over 	<p>Floor</p> <ul style="list-style-type: none"> - Instantiating and destroying - Stop the recreating at some points <p>Germs</p> <ul style="list-style-type: none"> - Attacking to blood cell - Reduce health - Die - Syncing on the floor
<p>Blood Cell</p> <ul style="list-style-type: none"> - Running - Sliding 	

Figure 3.3: Identified Game Functions and Requirements

Since the application aiming children years between 10 – 14, game related graphics, sounds, and other assets should match their preferences. Also, they should have the basic knowledge to use a mobile phone when their parents allow to use it. Although gameplay demanding highly detailed game assets and background it should be considered when the game developing because it can raise performance issues.

3.2 System Design

Designing game elements are the most important phase of game development. Game elements are what make a game motivational, exciting and irresistible. Game element separately cannot make an engaging, immersive learning environment. The relationship between different elements is what makes a game engaging.

Among all game elements, aesthetics tend to be more visible for the player [32]. Therefore game aesthetics have to be carefully designed. Designing of the Germ Hunter used more colorful UI, cartoonish fonts to attract the youngsters. Used 'RED' as a base color of all UI's and level designs because of the game concept.

3.2.1 Game Elements

The abstraction of concepts and reality

Germ Hunter classified as a role-playing endless runner game. In Germ, Hunter player has to play the role of a blood cell. It has to go through the human vein while fighting with germs. The game environment and related assets will help the player to manage the conceptual space being experienced.

Goals

Blood cell has to fight with the germs while running through the blood vein. It has superpowers and can use enzyme boost gun to destroy germs. End of the game level player gets a chance to view AR content.

Conflict and Competition

Germs also can attack the blood cell. Both germ and blood cell lose energy/health when fighting. Sliding and jumping barriers spawn randomly to make the game more challenging.

Feedback

Showing feedback on the amount of score, killed germ count, collected power up, etc. on the game screen

Levels

Infinitely repeat running platform with level background assets.

Aesthetics

Appropriate and aligned visuals, attention to detail, simple contrasts or colorful backdrops create an immersive environment that contributes to the overall game experience. The cues and small details add to the game environment and convey meaning. Germ hunter aesthetics designed relevant to the target age group - youngsters. (colors, fonts, character design)

3.3 Game Assets

The game's visual experiences to the players are often achieved through the game assets. The game assets are often divided into art assets and script assets. The game art assets refer to the game models, model textures, game background music and etc. These art assets make up the in-game objects and user interfaces. Instead, scripts assets are the core parts of the game. These assets are programmed with the code which is responsible for the administration of the gameplay and rules of the game.

During this game project, images are designed to create the user interface, characters and scene items. Since this game project is a 3D infinite runner game, all 3D game models including characters, ground, background, obstacle, etc. are designed and created using Autodesk Maya. Pre-build animations were applied for the Player and Enemy characters using Mixamo open-source software.

3.3.1 UI Design

Game UI is related to all the interactions we made during the game. Development of Germ Hunter UI consists of a Splash(Fig.3.3), Start, Main Menu and In-game UI, both of which are at a very early stage of development and are not to be considered final.

Menus

The start screen (Fig.3.4) will direct to login (Fig.3.5) and register screen (Fig.3.6).

The main menu (Fig.3.7) is a simple set of different screens: settings (Fig.3.8), player performance board (Fig.3.9) and how to play. (Shown in Fig.3.10). The settings screen has a variety of adjustable values like music, effects. How to play screen will contain a description of the game. The leaderboard will contain player performance details. Run screen as shown in Fig.3.11 display the existing highest score of the player at the bottom left-hand corner. When the user taps on the run screen the game will begin.

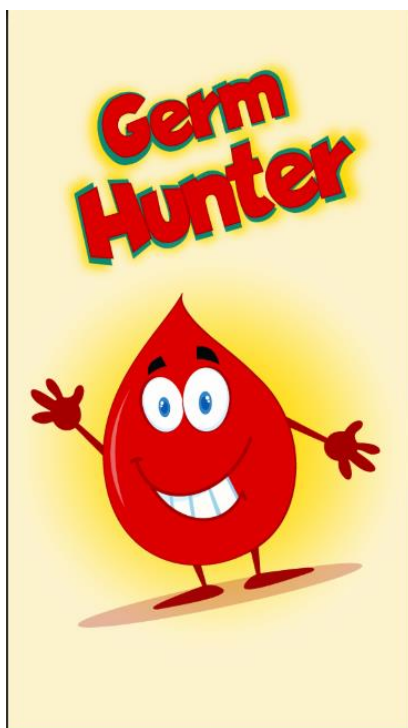


Figure 3.4: Splash Screen

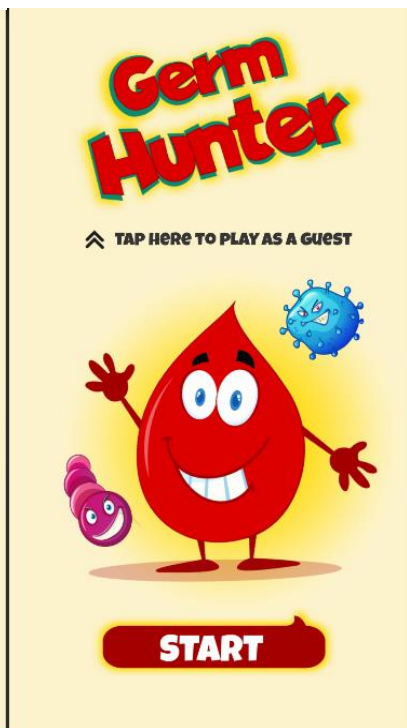


Figure 3.5: Start Screen

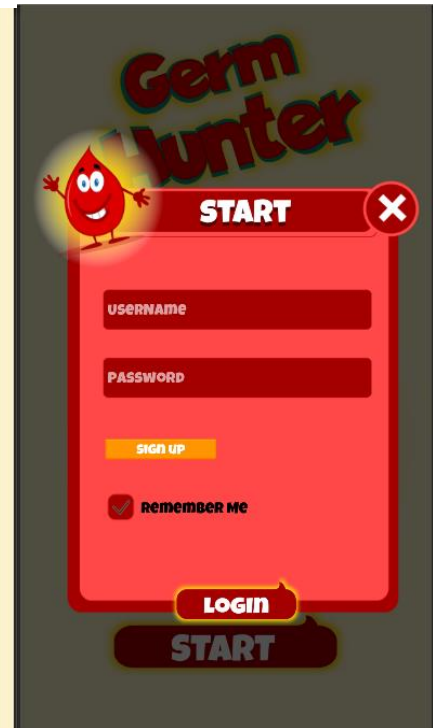


Figure 3.6: Login Screen

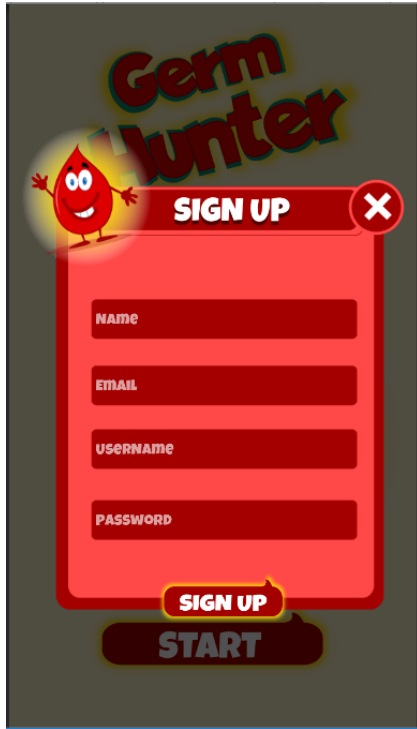


Figure 3.7: Register Screen



Figure 3.8: Main Menu Screen

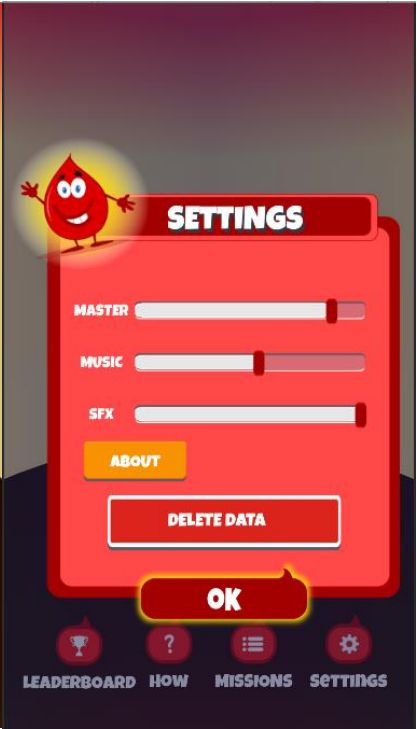


Figure 3.9: Settings Screen



Figure 3.10: Leader Board Screen



Figure 3.11: How to Play Screen



Figure 3.12: Run Screen

In-Game

The visible part of the in-game UI is a very minimalistic representation, with buttons for going back to the main menu and for game pause. Collected pickups, germ count, modifier speed and current score will display top of the screen. Game over screen pops up with the gained score and the collected pickups count when the player character died.



Figure 3.13: Game Screen

Figure 3.14: Game Over Screen

3.3.2 Character Design

Player Character and Enemy Characters

All the characters developed and textured using Maya and export them as .fbx files with embed the textures to Unity. Characters are modeled in t-pose because it's easy to apply a bone structure for animating them.

Player character – Blood cell is the main role of the game. Enemy characters – Germs are an active opponent of the player. Character's back story, personality, appearance, animations, and abilities are described further in GDD – Appendix A, page 64.

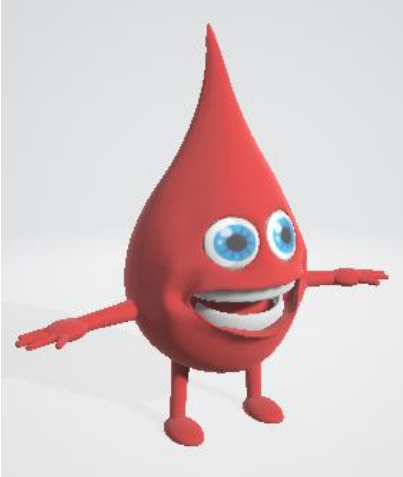


Figure 3.15: Player Character

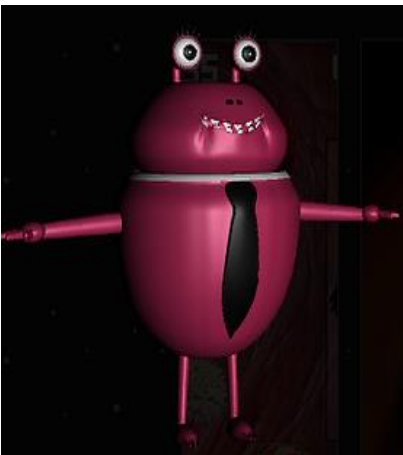


Figure 3.16: Enemy Character - 1

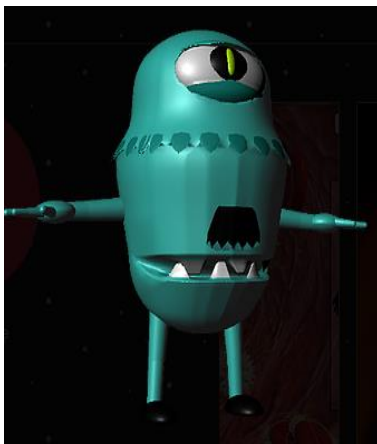


Figure 3.17: Enemy Character - 2

3.3.3 AI Design

The enemy will be spawned from the random destination when the game is started. When he sees the player, he starts chasing the player and if he reaches the player, he is going to attack him. Enemy characters have to attach navigation mesh agent to achieve above AI. Supporting AI components and the way it builds is described further in GDD – Appendix A, page 66.

3.3.4 Level Design

The level design of the game has a clear goal: to make levels that are short, dynamic and difficult. The difficulty and dynamicity of the levels are reached by designing the levels in such a way that the player never has more than a few seconds of time to think, having a soundtrack that adapts to the level's action and creating a running route with enough variety and different types of obstacles.

More on Levels is described on GDD - Appendix A, page 64.

3.3.5 Obstacle and Pickups

There are four different obstacle - 1 slide, 2 ramps, 2 long blocks, 1 jump and one type of pickup - a diamond in Germ Hunter. Jump, slide and long blocks consist of the death zone. These objects are modeled from Maya and textured inside Unity Engine.

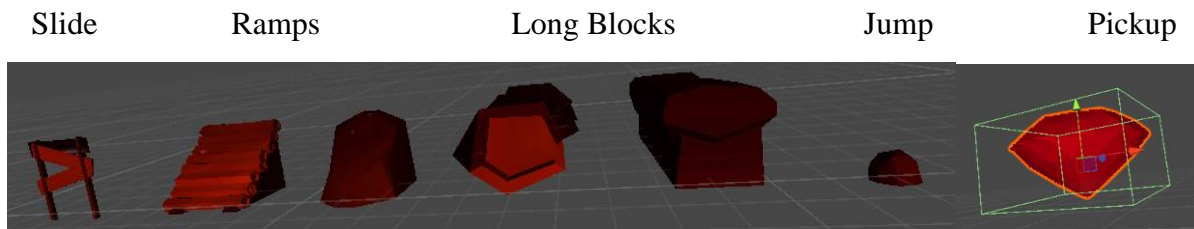


Figure 3.18: Obstacles and Pickups

3.3.6 Materials, Shaders, Skybox, and Textures

When putting the character into a game environment, usually needs to add materials, shaders, and textures, in order to make the character, look more realistic. When characters and other related assets importing as a .fbx form from Maya to unity, can embed the texture files with models. As shown in fig 13, diamond material is designed for pickups, floor and atlas material consist of shader script for bending effect which is designed to apply for floor and background assets. A skybox is a panoramic texture drawn behind all objects in the scene to represent the sky.

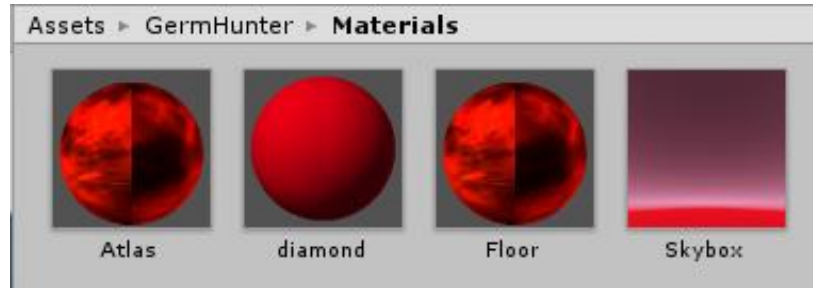


Figure 3.19: Materials

3.3.7 Animation

The animations of the characters are imported together with the model from Maya and controlled in Unity with the Animation Controller. In game animation like showing/hiding menus, spawning/collecting pickups are designed with unity Animation State Machine.

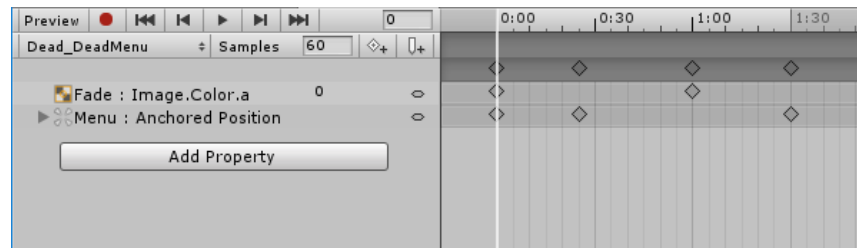


Figure 3.20: Death menu animation window

3.3.8 Colliders

Collider components define the shape of an object for the purposes of physical collisions[33]. 3D colliders are applied to the obstacles and pickups with separate tags. When a player collides with obstacles/ pickups certain game logic will enable under the defined tags. Player and enemy characters have mesh colliders.

3.3.9 Sounds and graphics

When considering the sound of the system all the sounds are presented in a manner that matches to the working environment and the activities of the system. Background music uses to keep the interaction on of the system. Special sound clips are used to encourage the kid when the successful completion is done for activities. All the graphical interfaces are created in a manner of keeping the interaction of the kids.

3.4 UML Diagrams

3.4.1 Use Case Diagram

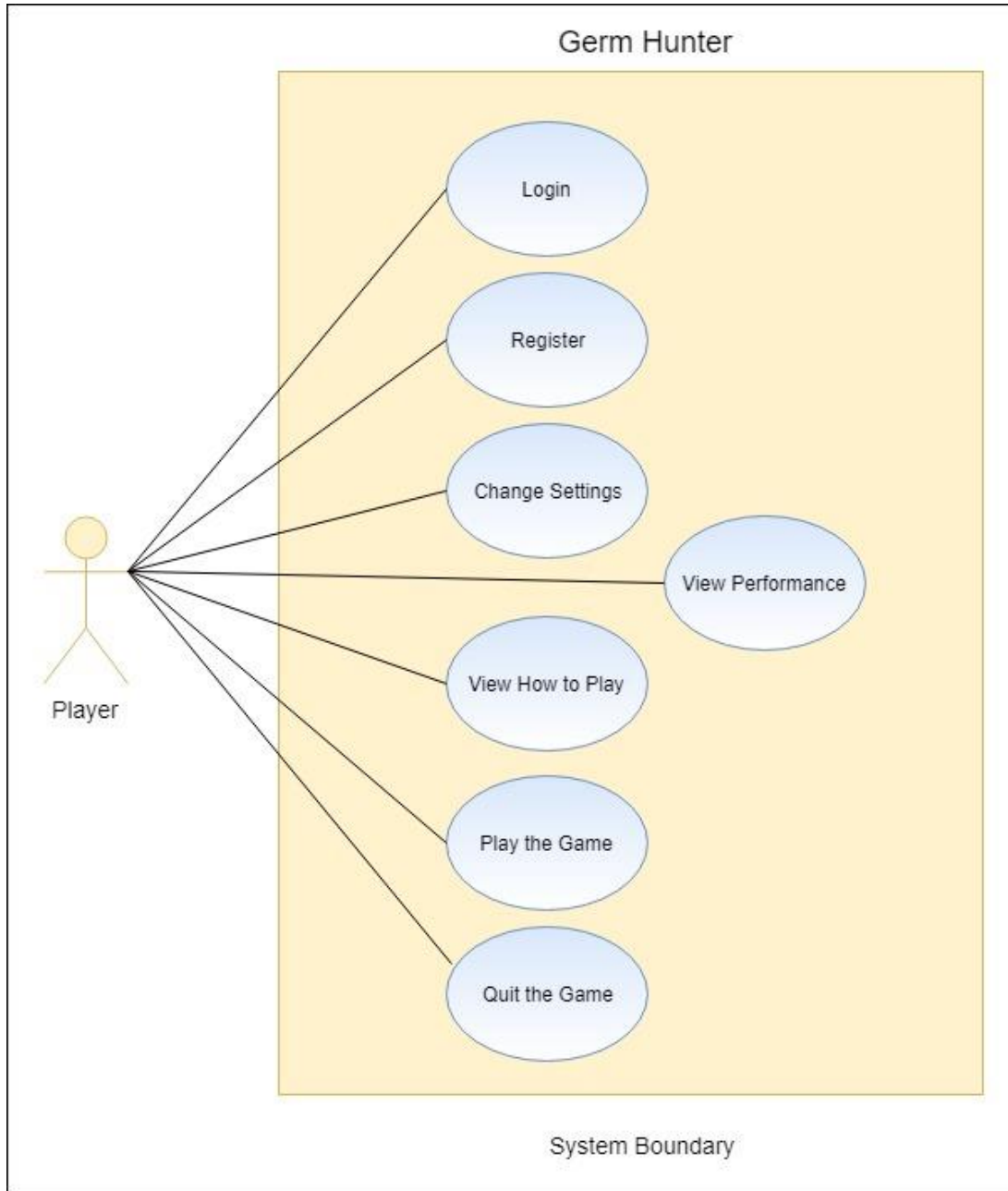


Figure 3.21: Use Case Diagram

3.4.2 Class Diagram

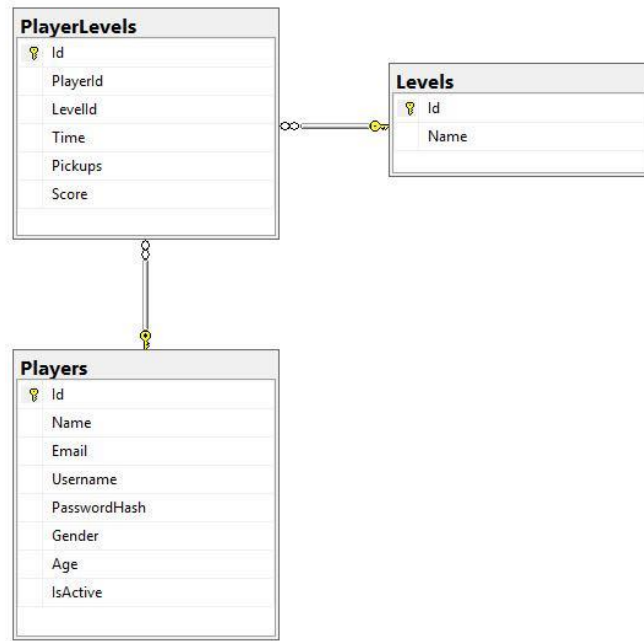


Figure 3.22: Class Diagram

3.4.3 Sequence Diagram

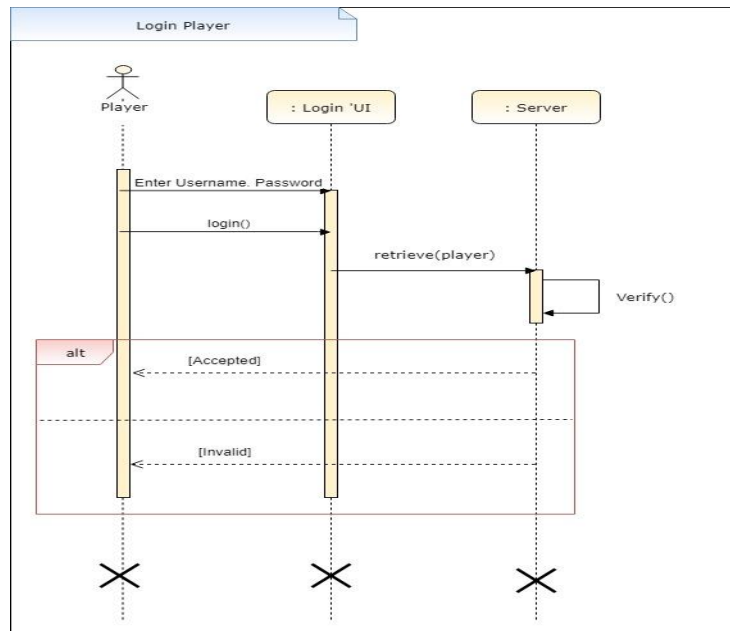


Figure 3.23: Player Login

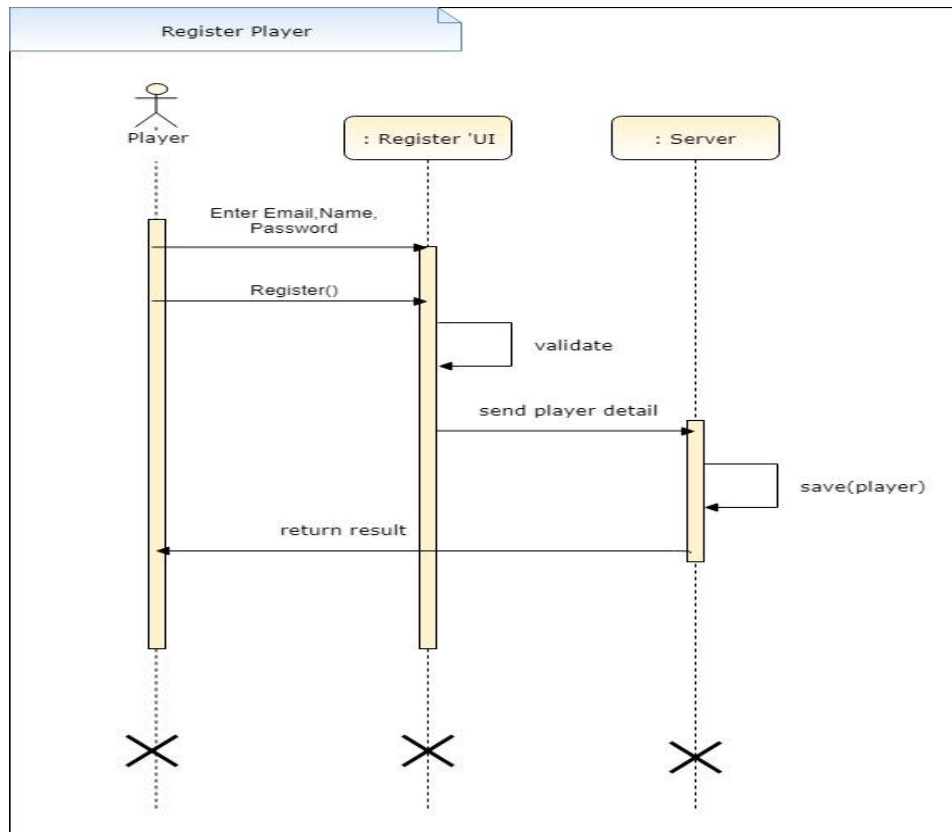


Figure 3.24: Player Register

3.5 Database Design

More design and implementation aspects were included according to the nature of the project. Maintain database only for player login registration and player performance.

3.5.1 ER Diagram

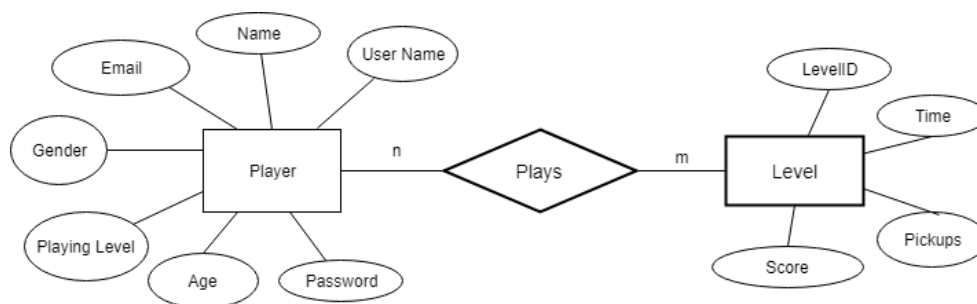


Figure 3.25: ER Diagram

3.6 Summary

Analysis and Design in game development were mainly considered about GDD. A game design document is a blueprint from which a game is to be built. As such, every single detail necessary to build the game should be addressed. Furthermore, game design prototype implementation was done during this chapter to identify improvements and drawbacks of the design aspects.

4 Implementation

In the previous chapters, discussed the basic theoretical background of the game balance, game design, and game programming with Unity and Unity features. As the final goal of the project, this chapter will discuss the implementation stage of the game development process.

4.1 Implementation Technology

Unity

Vuforia SDK[35]

Visual Studio – For unity scripting and API implementation

Autodesk Maya – For modeling 3D characters and assets

Mixamo – For character animation

Adobe Photoshop & Illustrator – For Designing GUI and textures

SQL Server Management Studio(SSMS) - To manage a SQL Server database

4.2 Implementation of game assets

A full 3D-game with many high-quality elements in the game would demand the current mobile device generation, so the solution is to use low polygon 3D elements in the main gameplay area, with the layers in front and behind of the player having pure 2D-graphics.

Including highly detailed backgrounds assets and graphics as the game needed, will be causing gameplay slow and performance of the mobile lags. Because of the same performance issues experience gained by developing a prototype version of Germ Hunter, decided to use low polygon background assets with one running platform.

4.2.1 Running Platform

Starting the game stage, first, need to create the basic ground to let the main character idle/run on it. Default Unity 3D Unity plane is used as a running platform of Germ Hunter. Plane generates with Mesh collider so that the ground can contact with the all others game assets. Also, the collider can let the character stand on the art assets in the physical environment.

Germ Hunter is used one plane as a running platform and allow it to follow the “Player” object. The plane is attached with a script called “FollowPlayer”. At the start, it finds player transforms and changes the potion of the plane frame by frame along with the player position in “z” axis.

```

playerTransform = GameObject.FindGameObjectWithTag("Player").transform;
transform.position = Vector3.forward * playerTransform.position.z;

```

To get the bending effect use shader script with the floor material for the running platform.

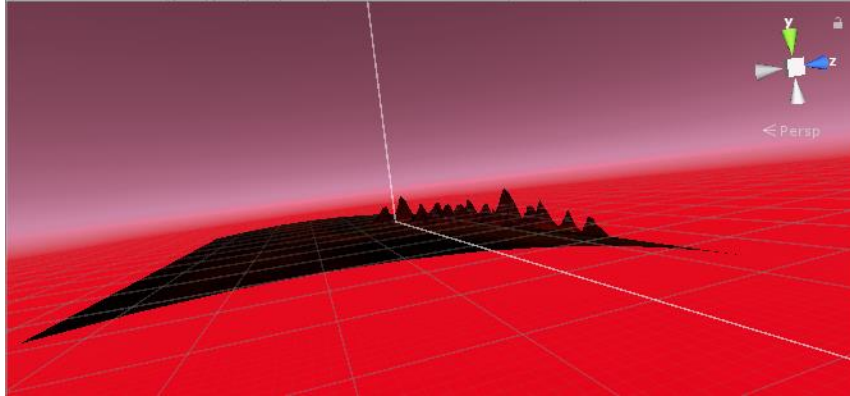


Figure 4.1: Player running platform

4.2.2 Background Assets

Background also attach with the shader script to get the bending effect along with the running platform. “BackgroundSpawner” script which is attached with background assets allow respawning the background child element alongside player transform. When the difference between the player position in the z-axis and the respawn distance (constant value) is greater than the background 1st element position, it respawns the current 1st element in a new position. Accordingly, the background element spawns again and again along with the player transform.

```

if (transform.GetChild(0).transform.position.z < playerTransform.position.z -
Constant.DISTANCE_TO_RESPAWN)
{
    transform.GetChild(0).localPosition += Vector3.forward * totalLength;
    transform.GetChild(0).SetSiblingIndex(transform.childCount);
}

```

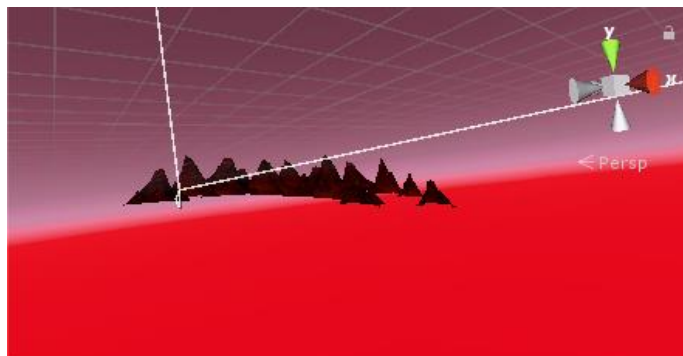


Figure 4.2: Background assets

4.2.3 Obstacle and Pickups

Five basic, simple segment are created as level elements to provide a range of barriers to the player. Each segment consists of different type of pieces spawner and pickups. Pieces spawner allow spawning pieces on spawner objects depending on the piece types. Pieces, pieces spawner, pickups, and segment are created as prefabs separately for later use. The main object of using prefabs is to allow the game objects and resources to be reused during the game process. Prefabs can improve resource utilization and efficiency of the development in this project. It is important to create prefabs for each of them.

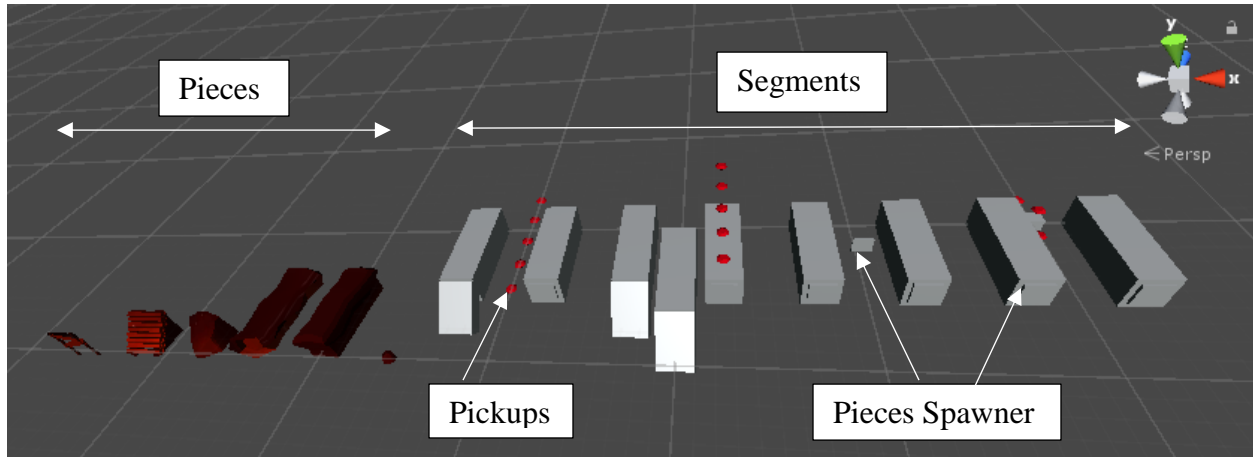


Figure 4.3: Obstacles and pickups

Pieces

All the pieces are in different shapes and sizes of the 3D model. Each piece has its own type (jump, slide, ramp, long block) and visual index. Pieces are applied with shader material and create the prefabs of them.

```
public class Piece: MonoBehaviour {
    public PieceType type;
    public int visualIndex;
}
```

Pieces Spawner

All the Pieces spawners are default primitive 3D cubes in Unity. Each spawner object is in the same size with a relative it's a piece. Some of the pieces spawner consist of death zone (jump, slide, long block). Each object attached with PieceSpawner script which allows to spawn and despawn on a request of a segment.

```
public void Spawn()
{
    int amtobj = 0;
    switch(type)
    {
        case PieceType.jump:
            amtobj = LevelManager.Instance.jumps.Count;
            break;
        .....
    }
}
```



```

.....
.....
    case PieceType.ramp:
        amtobj = LevelManager.Instance.ramps.Count;
        break;
    }
    currentPiece = LevelManager.Instance.GetPiece(type,
Random.Range(0,amtobj));
    currentPiece.gameObject.SetActive(true);
    currentPiece.transform.SetParent(transform, false);
}

public void Despawn()
{
    currentPiece.gameObject.SetActive(false);
}

```

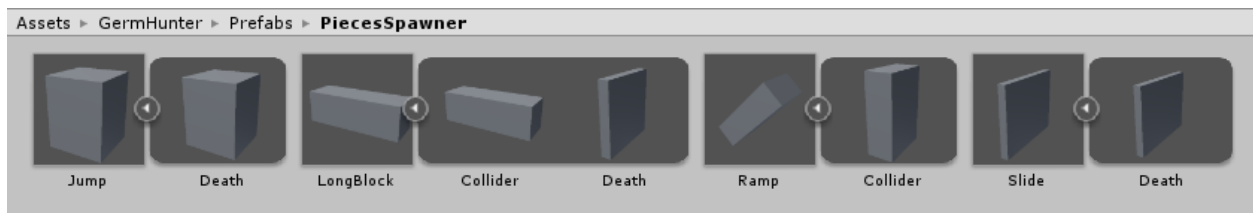


Figure 4.4: Pieces Spawners

Segment

A segment consists of three types of pieces spawners and pickups in a challenging way to the player. All segments spread within the three lines of the x-axis in the ground. Each segment has defined properties for length, starting and ending position in the y-axis. Segments are generated based on the above properties randomly by Level Manager.

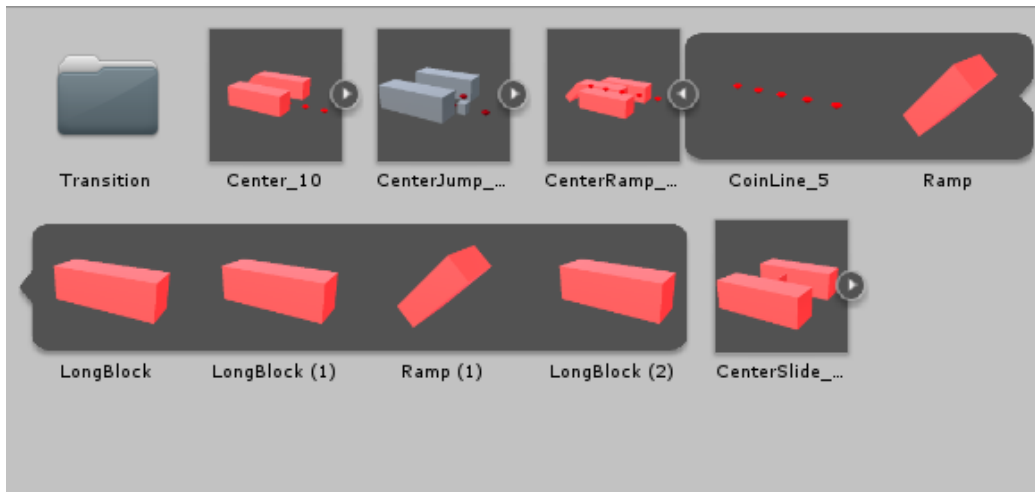


Figure 4.5: Segments

Pickups

Pickups are separate prefab in the segment. Coin line and coin arc are the two types of pickups used in Germ Hunter. Each coin consists of box collider, animator controller, a material with shader script. Triggering animations and collecting coins controlled by the script attached to each coin. Coin line or coin arc are managed by the coin spawner script. It defines chances to spawn and the maximum coins for the coin line or arc.

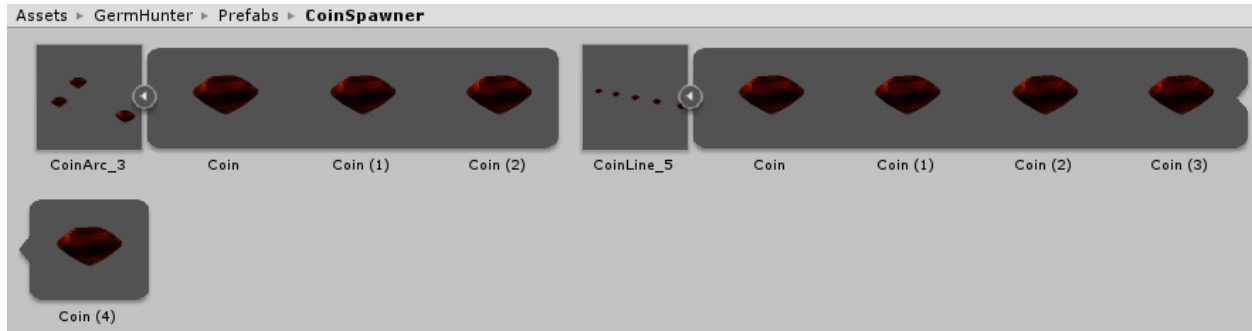


Figure 4.6: Pickups

Level Manager

Level Manager is an empty game object in the hierarchy section. Script attached with the level manager randomly generate and control all the ground assets. Level manager defines the list of each piece, segments, and transition as in Figure 4.7. During the game process, each ground prefab will be instantiating under the Level manager, as in Figure 4.8. It allows making the hierarchy more concise and specific.

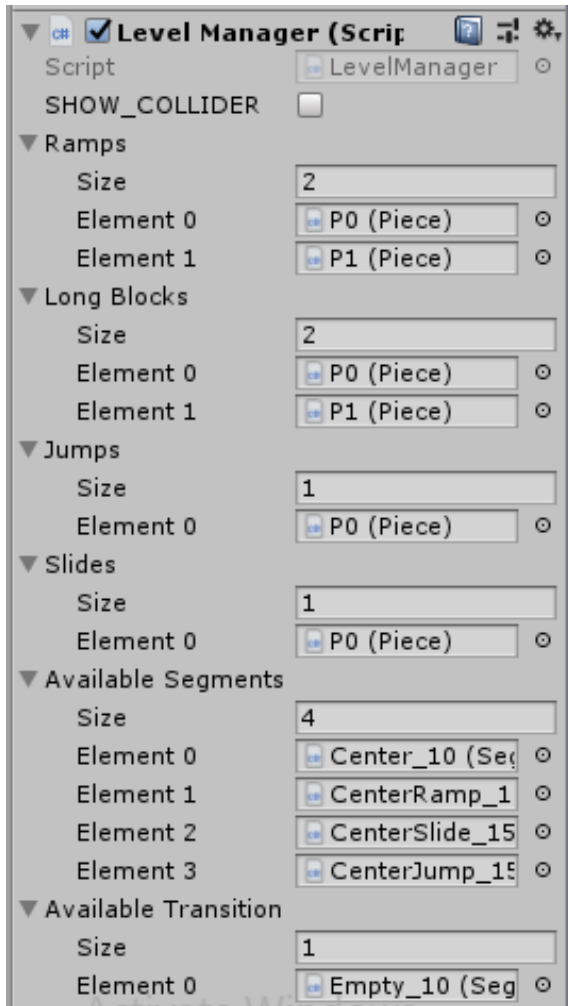


Figure 4.7: Level Manager Script

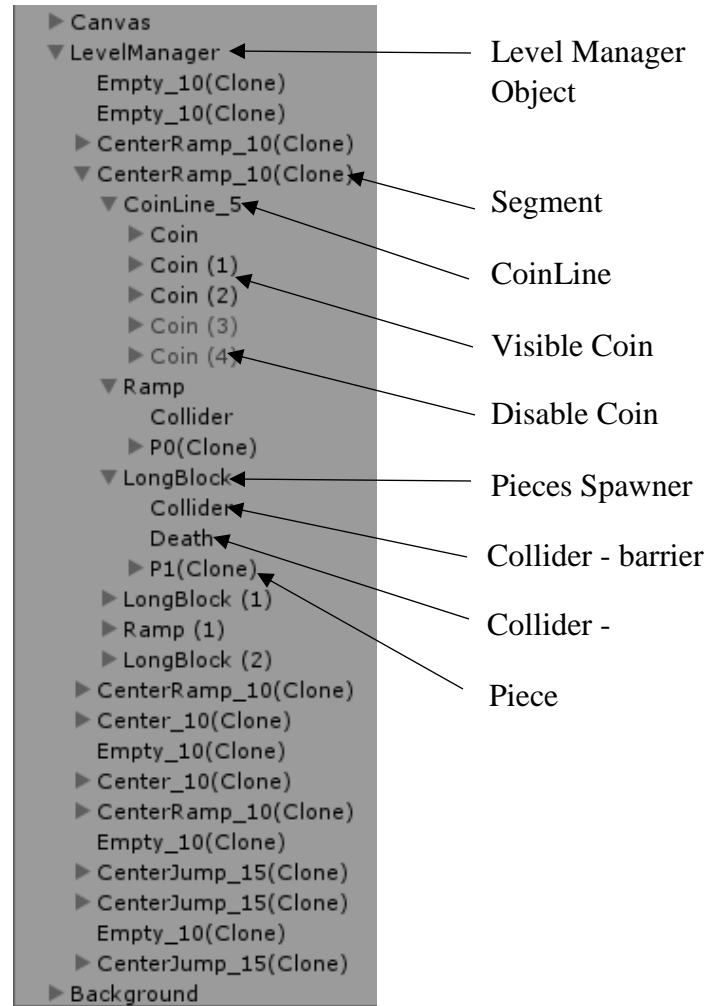


Figure 4.8: Segment initiate under level manager

4.2.4 Player Character

A most important element of the game is the main character. The players will control the game character to reach a higher challenge during the game time. In this project, the character needs to add a set of animation, so that it will move in motion. The main character is exported Unity engine with pre-built basic animation clips (idle, run, jump, slide, death). As shown in figure 4.9 all the player animations control in Unity animation controller.

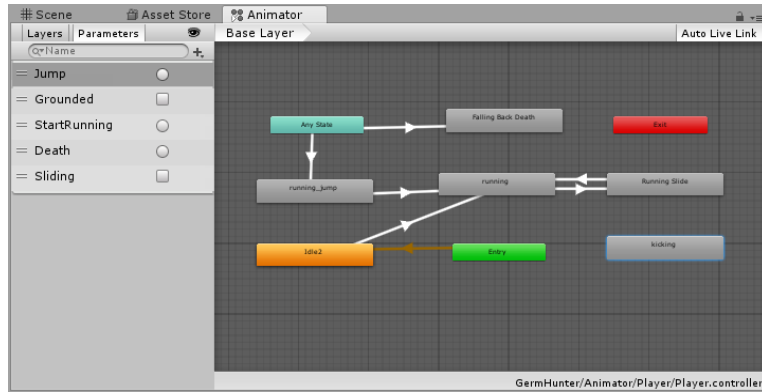


Figure 4.9: Player Animation Controller Window

The Player's Animator Controller is more complex and in addition to toggles uses Booleans, trigger parameters. The animation is enabled/disabled based on the mobile touch input or mouse input values. Each animation transition happens if it's the condition is satisfied.

Character controller component added to the player that allows doing movement easily constrained by collisions without having to deal with a rigid body. A CharacterController is not affected by forces and will only move when you call the Move function. It will then carry out the movement but be constrained by collisions.

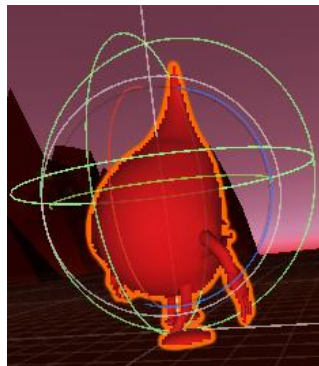


Figure 4.10: Player Character Controller

After the animation and properties of the character are done, need to add control to the character with some scripts. Since the character will run and jump/slide during the game process, the animation needs to switch between these two actions. Therefore, we need to give a parameter to the character in the Animator, like in Figure 4.12.

As an example - Running and sliding animations need to be connected to each other in the Animator by the transition components (Figure 4.11). Afterward, all the transitions need to be added a boolean parameter in the conditions setting called "Sliding", so that when the character takes an action and reaches the condition, the animation will switch to another one.

On the other hand, we also should give more details of the conditions with codes, so that the character can be allowed to switch the animation in the game. The animations are divided into two judgments in the codes. if a player swipes down the finger on the mobile screen, the parameter is set to true in the conditions to play the jump animation. Then, Player controller invokes the “StopSlidding” function to the setting value, the parameter is set to false to play the running animation, as in below.

```

Private CharacterController controller=
GetComponent<CharacterController>()if (MobileInput.Instance.SwipeDown)
{
//slide
StartSliding();
Invoke("StopSliding", 1.0f);
}
private void StartSliding()
{
anim.SetBool("Sliding", true);
controller.height /= 1.2f;
.....
}
private void StopSliding()
{
anim.SetBool("Sliding", false);

controller.height *= 1.2f;

.....
}

```

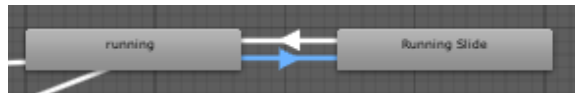


Figure 4.11: Running - slide animation state

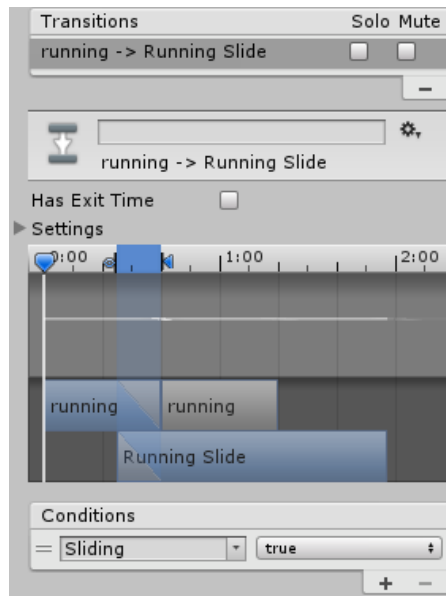


Figure 4.12: Running - slide animation state

Also, the character will be in contact with the enemies and obstacle within the game. Like in most games, when the character contact with the dead colliders, the character will trigger the death animation. In this project, this animation will be achieved through the codes shown in below.

```
private void Crash()
{
    anim.SetTrigger("Death");
    isRunning = false;
    GameManager.Instance.OnDeath();
}
```

Player movement on the ground

Player character is allowed to move forward within three lanes on the ground in the z-axis. According to the user's touch phase direction, it decides the current moving lane.

```
private int desiredLane = 1; // 0-left, 1-middle, 2-right

if (MobileInput.Instance.SwipeLeft)
    MoveLane(false);
if (MobileInput.Instance.SwipeRight)
    MoveLane(true);

//calculate where we should be in the future
Vector3 targetPosition = transform.position.z * Vector3.forward;
if (desiredLane == 0) {
    targetPosition += Vector3.left * Constant.LANE_DISTANCE;
}
else if (desiredLane == 2)
{
    targetPosition += Vector3.right * Constant.LANE_DISTANCE;
}

public void MoveLane(bool goingRight) {
    desiredLane += (goingRight) ? 1 : -1;
    desiredLane = Mathf.Clamp(desiredLane, 0, 2);
}
```

4.2.5 In game objects

The player character will be in contact with the enemies within the game. Like in most games, when the character contact with the enemies, both characters loss their health gradually and finally trigger the death animation. In Germ Hunter enemies are spawned randomly and follow the player.

During the game process, the character needs to avoid/kill the monsters on the platform. The enemy has basic components such as Renderer and Collider3D. In addition, NavMeshAgent attaches to the enemy component. The agent will automatically move along the path until it reaches its destination – Player Character.

The position of the enemy on the grounds is generated randomly with the codes. Another very important in-game item is the reward coins. The character is not just earning points by moving

forward to reach other grounds. Also, the reward coin can give bonus points to reach a high score. The reward coins have some basic principles compared to the monster. But the coin will disappear when the character collected it and then it will be respawning.

Therefore, players need to control the character to get the coins as much as they can. At the same time, they also need to dodge enemies to avoid death. All these in-game objects can make the Germ Hunter more flexible and fun.

4.2.6 Score Records

In this game, the high score is to measure the distance that the player has reached so far. Also, the coins give bonus points. When the player reaches a new higher score, the high score record database will replace the old with the new score.

In this game, it is necessary to use GUI to display the score and high score on the platform. The current score is to tracking the current score that player achieved during the game process. The high score is to show the highest score so far. Killed enemies count and the collected coins count also displayed in-game screen (Figure 4.14).

When the game starts, the current score will start counting the points that the character achieved. Also, the high score record will keep the previous high score until a new one replaces it. It looks like in Figure 4.13.



Figure 4.13: Run Screen

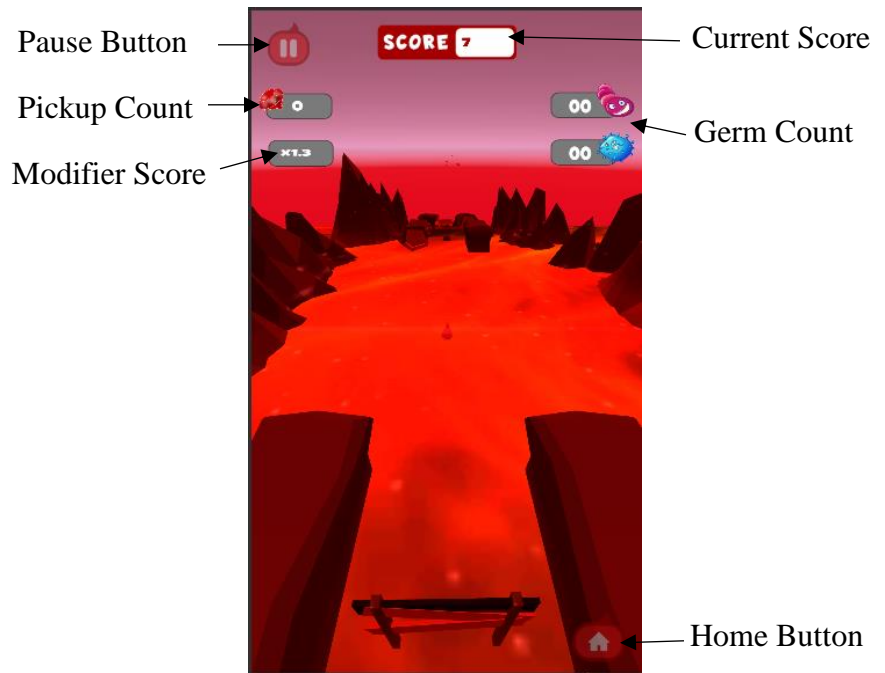


Figure 4.14: Game Screen

4.2.7 Graphics, Sound, and Language

Lightening, 3d modeling, texturing, support GUIs and shader scripting are the main graphics component of the GermHunter. Game graphics were developed to achieve a high concept as much as possible. Some textures are downloaded from the internet instead of creating from the beginning.

Background music and sound effects added extra appealing to the game, Sound and language setting can be done in the Setting screen. Although the application's default language is English user can select the language as Sinhala according to his/her will.

Simply create one XML file with the strings that have multiple translations and then reference those strings in "XMLReader" script with a common identifier. The XML format is as follows:

```
<languages>
  <language>
    <Name>English</Name>
    <button1>Play</button1>
    <button2>Exit</button2>
  </language>

  <language>
    <Name>Sinhala</Name>
    <button1>සෙසෙම් කරන්න</button1>
    <button2>පිටවීම</button2>
  </language>
</languages>
```

Once the XMLReader Class has been initialized to a particular language, it can reference the strings stored in Languages XML file as follows:

```
languages[currentLanguage].TryGetValue("Name", out languageName);
languages[currentLanguage].TryGetValue("button1", out button1);
languages[currentLanguage].TryGetValue("button2", out button2);

qwe1.text = button1;
qwe2.text = button2;
```

4.3 Game Features

4.3.1 Movements

The main gameplay element of the player running is achieved by applying a velocity on the z-axis to a Character Controller component (Picture 4). Picture 4, PlayerController in Script. Other basic player movements are done by the triggering relevant animation based on the user touch phase direction.

The game scene often moves in the z-axis. With the movement of the scene, the level of the ground will change frequently. In this game, the grounds and backgrounds need to be in motion.

Since the game is in three-dimensional perspective, need to configure the axis X, Y, and Z. The grounds and backgrounds are edited with the different game speed in real time. The game speed of the backgrounds is much slower than the ground, which makes the game seems more realistic. In addition, the default game speed is increased gradually, as Code 2 shows.

```
if(Time.time - speedIncreaseLastTick > speedIncreaseTime)
{
    speedIncreaseLastTick = Time.time;
    speed += speedIncreaseAmount;
    //change the modifier text
    GameManager.Instance.UpdateModifier(speed - originalSpeed)
```

4.3.2 Controls

All game components controlled by GameManager script including UIs. And there is specific script run for controlling camera, levels, player and user input. They control all the game objects with defined logic and game mechanism.

The main Camera looks at the player object and follows behind with constant offset on a LateUpdate. LateUpdate is called after all Update functions have been called. Follow camera should always be implemented in LateUpdate because it tracks player that has moved inside Update.

Jumping and sliding are the main controls of the player. First, the jump ability gets values set in the PlayerController script for the initial jump force and also determines that jump cannot be used while jumping. Then nothing is done until input from the player is received and the ability is turned on.

Once input is received, the PlayerCharacter's current animation is deactivated and the animator is told that the player is no longer in touch with the ground by setting the Boolean "isGrounded" to false, which starts the jumping animation. Jumping is set to true and the jump is also added to a jump calculator just for the sake of statistics. Jump's effect is added to the Player's velocity by setting the y-velocity to be equal to the JumpForce and gravity is manipulated for a better, more realistic falling speed after the jump.

```
verticalVelocity -= (gravity * Time.deltaTime);
//fast falling
if (MobileInput.Instance.SwipeDown) {
    verticalVelocity = -jumpForce;
}
```

The slide is used to go through narrow barriers that are impossible to run through (Figure 4.15). When the sliding activated, the height of the player controller is reduced, thus allowing the Player to go through much narrower passages.

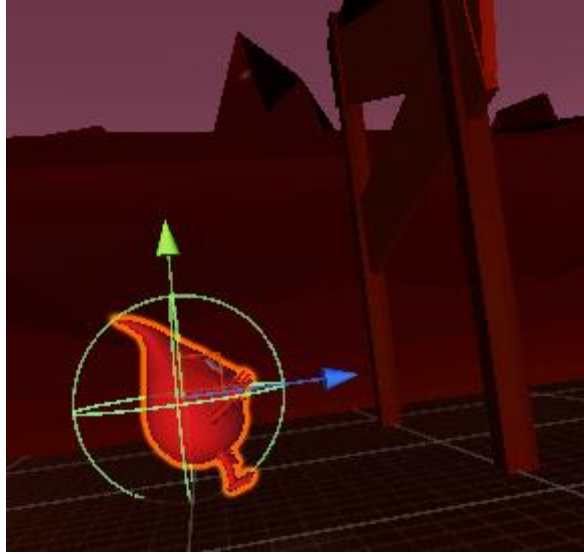


Figure 4.15: Player Controller sliding

4.3.3 Collisions

The collisions in the game are relatively simple. When a controller hits a collider with a relevant tag while performing a move, it triggers certain logic under the tag in `OnControllerColliderHit`.

In *Germ Hunter*, some obstacle has two colliders. One is used as a dead zone other one is for the barrier. Dead collider is attached with a specific tag. As an example, if the player collides with long block front face it will die. But rest of the faces in the long block not act as a dead zone. Death collider is tagged as "Obstacle".

```
private void OnControllerColliderHit(ControllerColliderHit hit)
{
    switch(hit.gameObject.tag)
    {
        case "Obstacle":
            Crash();
            break;
    }
}
```

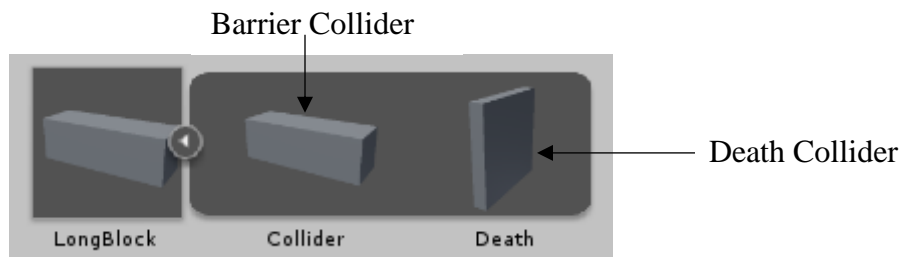


Figure 4.16: Longblock Spawner

4.3.4 Animations

Interaction between the game characters and the game objects should be adjusted in the Animation State Machine. In addition, animation state is frequently used in Germ Hunter. Other than the characters most of the menu components are maintained animation state to hide/display when it needed. Game menu animation controller is shown below.

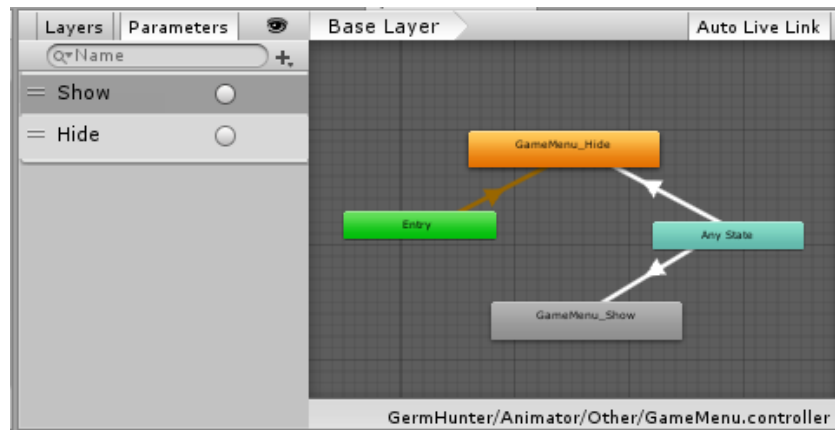


Figure 4.17: Game menu animator controller

4.3.5 System AI

NavMeshAgent which is attached to the enemy characters always follows the player character by setting its destination to the player's position as follows :

```
Transform player;  
UnityEngine.AI.NavMeshAgent nav;  
  
void Awake(){  
    player = GameObject.FindGameObjectWithTag ("Player").transform;  
    nav = GetComponent<UnityEngine.AI.NavMeshAgent> ();  
}  
void Update () {  
    nav.SetDestination (player.position);  
}  
}
```

4.4 API Implementation

RESTful web service using ASP.NET Web API was implemented for login, register and leader board analysis.

4.5 AR Components

Vuforia SDK is integrated into the Unity Engine to achieve this component. The default way Vuforia works is with Image Recognition. Image Recognition, also called Tracker Recognition or Image Tracking, is the process by which the camera detects a predetermined image and knows what to do with it, such as rendering some content on top of it [34].

When a player successfully achieved a relevant score, AR level is enabled. Then the user can see the internal human organ using the app icon as a target. 3D Models of internal organs in the AR components are downloaded from the free available sites.

4.6 Summary

This chapter was focused on the implementation of the gameplay design component and how they behave with each other. Implementation of each game assets and system features described in concise.

5 Evaluation & Testing

5.1 Introduction - Mobile Game Testing

Mobile game testing differs from regular mobile application testing. Effective mobile game testing derives from a well-structured and systematic approach. Testing in general, but applying also to game testing, there are two different forms of testing that can be categorized as a Black-Box and White-Box testing. These definitions are well-known in the software testing world but process-wise isn't different from game testing. Only their goals are slightly different in-game testing:

5.1.1 Black-box testing

Focuses on the functional and overall playability aspects of the game. In this type of testing, for example, testing the graphical user interface, user experience or any visual appearance is in the key role. Menus, graphical elements, special effects, animations, and the actual gameplay are those under test with Black-box approach.

5.1.2 White-box testing

Focuses on the architectural, integration and systemic aspects of the mobile game: how third-party components, databases, social media/external entities, as well as graphics/game engines, audio player and so on are integrated into your game.

5.2 Methods Used In Mobile Game Testing

The testing methodology and used forms of testing aren't too different from application testing. The most important ones when it comes to mobile game testing are as follows:

5.2.1 Functional Testing

A most common method in mobile game testing under the black box testing technique. Typically functional testing is associated with manual testing and playing 'game through'. The User Interface and overall functionality of it has a direct impact on how successful Germ Hunter will be

Determined whether the Germ Hunter is working according to the specifications. In Germ Hunter, functional testing looked for gameplay issues, graphics issues, audio-visual issues, screen orientation, and screen resolution, font size, alignment errors, usability, system navigation such as loading time, animations elements aspects, etc.

UI layouts and elements:

Germ Hunter targeted for a maximal set of different screen resolutions and different types of screens.

Menu structure and functions:

Tested menu structured, functionality and correct behavior and it's navigation.

Screen orientation:

Germ Hunter works only portrait mode.

Screen resolution:

There are lots of screen resolutions, especially on Android. Germ Hunter tested across these different resolutions to ensure that the graphics do not get stretched.

5.2.2 Compatibility testing

Used to find whether a game is functioning properly or not with respect to the hardware, graphics and software configuration that the device is built with. It is one of the essential mobile application testing processes that check if a game title is able to run on specific devices.

In Germ Hunter Compatibility testing

- Validate whether the user interface of the app is as per the screen size of the device and ensure high quality
- Ensure whether the text is readable for all users
- Ensure that the product meets all necessary requirements set by the developer
- Install and uninstall the game on all supported mobiles.

5.2.3 Performance testing

The overall performance of the Game is checked. Performance tuning is performed to optimize game speed. Related to performance testing it is important to understand how used device ecosystem varies and what are actual requirements of the game for its users.

In Germ Hunter Compatibility testing:

Game Startup - How much time the game takes to start up?

It is the first game performance parameter adjudged by the user. As a thumb rule, after the user taps on a game icon the first screen should be shown in 1-2 seconds. Germ Hunter Splash Screen loaded within 1-2 seconds after the tap app icon.

After the various testing performed, identified that there is an issue with performance, Striking graphics, rich media, animations, and their effects makes the Germ Hunter attractive, but it causes Gameplay slow and performance of the mobile lags. Decided to replace high polygon models with low polygon models and to use other performance improving technique as well.

5.3 User Acceptance Testing and Evaluation

After performing the system testing, the bugs that occurred are developed. Then the target group (Youngsters) performed the user acceptance testing. The target group consists of selected children age group between years 10 - 14. They allow to run the game with parents' permission and came up with some more modification to the requirements. The basic functionalities of the system have already been tested with a 14 years old kid.

A sample of players with varying skills in playing the mobile game was approached and asked for their participation in testing and appraising the Germ Hunter. The sample used for testing the Germ Hunter was my colleges' relations, neighbors and some of the relations. All the selected respondents having Android mobile phones and agreed to allow their child to play the game. These samples were selected because they are representatives of the target users of the application.

Since the application targeting children age group between year 10 - 14, have decided to get their parent's feedback as well. It is important to get both perspectives from children and their parents about the usage of the mobile phones, addiction of mobile gaming among the Sri Lankan youngsters, as well as how much aware of mobile gaming techniques, it's capacity and usage. The designed questionnaire had two parts, part 1 for the child and part 2 for the parents. The responses from the user acceptance testing formed the basis of a summative evaluation of the application.

It was handed out to 16 parents and asked them to fill it's part 1 based on their child's.

5.3.1 Evaluation of Results

A total of 9 questionnaires were handed out to potential parents and asked them to fill both parts based on their child's answers and based on their opinions. A total of 7 questionnaires filled by myself based on players and their parent's answers.

Please refer the Appendix B for the questionnaire sample and the result summary of the target group's feedback with the charts.

Although the above evaluation of results regarding the overall application, there is an internal questioner for players' to evaluate their memory. Those questions based on internal human organs that players' ability to view with AR technology.

5.4 Test Plan & Test Cases

Test cases were developed for the basic function of germ Hunter(Login and Register). The test cases include all test scenarios, expected results, and the actual results.

Please refer the Appendix C for the Test cases and its' results.

6 Conclusion and Future Work

6.1 Conclusion

The aim of the study was to create a 3D endless running mobile game with the Unity 3D game engine. During this project, all the basic features were achieved completely endless running game on a mobile platform. Most of the game assets were created with Photoshop and Maya software. In addition, all the assets in the game have some components to contact with other objects in the game. AR component implemented through the Vuforia Unity SDK. The tutorial section is connected with the AR level for evaluating players memory after viewing human internal organs in 3D.

During this project, I gained a deeper understanding of the features of the Unity3D game engine, fundamental knowledge of game programming, GUI designing and API implementation.

The main objective of this project is to present a mobile game with some educational value using youngsters' mobile phone addiction and the likeness of experiencing new technologies. This report presents the design, implementation, and evaluation of creation of Endless Runner 3D mobile game. All the user interface design were done through the Adobe Illustrator focusing the target audience. And the other graphics were completed through the Adobe Photoshop, Autodesk Maya and default Unity features itself. The basic graphics rated 65% over other features of the Germ Hunter according to the tests done in the previous chapter. The proposed application is easier to handle by non-experts as well as familiar users because it is too easy and enjoyable to play based on the results of the user evaluation.

6.1.1 Problem Encountered

There were a few problems and difficulties during the implementation of the project. Because of the gameplay based on the inside the human body, it was hard to design game levels realistic manner. Since this is a 3D game most of the game assets including player character were modeled in 3D. The issue came up when application trying to build on a mobile platform. The application should be in light weighted in order to run in mobile. After the experiencing Gameplay slow and performance of the mobile lags during performance testing had decided to rebuild some of the game assets with low polygon count.

Lack of knowledge and skills towards 2D game art designing was the other major problem encountered during the implementation. Some of the gameplay ideas couldn't be able to make life such as human body internal process and make the player feel like running through the blood vein. Those ideas will be implemented future after practicing 2D game art design.

6.2 Future work

There are plenty of research opportunities for future work. This approach can be extended to increase the degree of freedom in designing in developing educational games for various aspects.

This concept can apply for large theoretical and complex subjects in a creative manner.

On the other hand, there are still many features that can be added into this game, more in-game objects and game level design is necessary to make the game more interesting. Especially game levels can be designed to illustrate real internal human organs' processes. Also, the current in-game objects and the main character can add more features, such as more frames for the animation of the character to make it look more natural. This project still has a very large development space.

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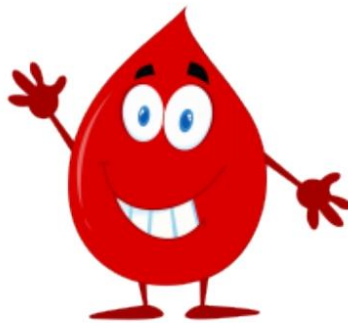
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Appendix A - Game Design Document

Germ Hunter

Infinite runner game embed augmented reality with
Educational content

Game Design Document



Dashani Abeywickrama

2019

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1 Game Overview

1.1 Theme

Use mobile game addiction to educational purposes.

1.2 High-Level Concept

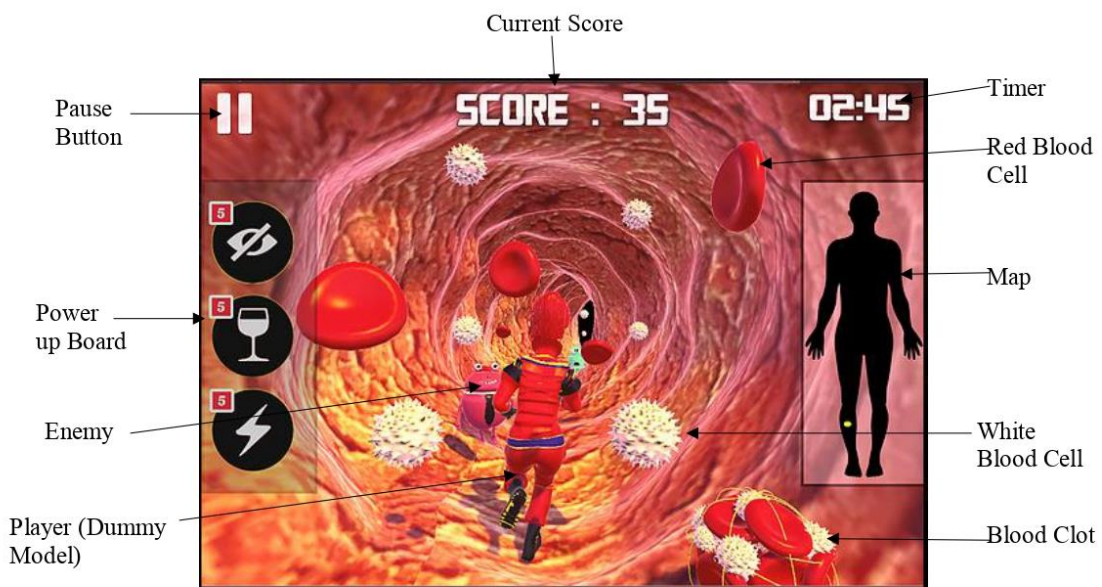


Figure 1.1: High-Level Concept of the Germ Hunter

1.3 Genre

Action, Educational

1.4 Target Audience

Youngsters (Children between ages 10 -14)

1.5 Motivation

Young people addictive to mobile phones

1.6 Game Flow Summary

Through the Framing Interface

- Player has to register an account
- Log in with the username and password
- Navigate to Main Screen
- The player can navigate settings, tutorial, leaderboard and how to play screens and do relevant action.
- Play can navigate the game by selecting the “Run” button on the main screen.
- Player has tapped on the start screen to start the game.

Through the Game

- The player runs on the platform
- The platform follows the player.
- Background and other assets generated infinitely.
- The player can swipe left, right, up, and down to control the character.
- Player has to avoid an obstacle, collect pickups and kill the germ while running on the platform.
- Player collect score by running safely, killing germs and collecting pickups.
- Player gradually lost his health when he contacts with the enemies.
- Player will die when health becomes zero or hit by the obstacle.
- The player can replay the game.
- Based on the score AR feature and tutorial set enable to the player.

1.7 Look and Feel

Germ Hunter is a cel-shaded style game. The cel-shaded visual style makes the game seems like a cartoon. Select the cel-shaded as the visual style because want the players to feel like they are playing in a fantasy world not the real world and also making sure that the players are playing in a fun environment and not as serious.

2 Gameplay and Mechanics

2.1 Gameplay

Germ Hunter is a mobile game which will be implemented in Unity game engine. It is an endless runner with a finite amount of premade levels, thus the term finite runner. Player has to play the role of a Blood Cell which is running through the vein. The gameplay consists of collecting different varieties of power boosters, avoiding obstacles and hostile creatures all the while running through the fantasy world. Blood cell has to fight with the germs. Germs also can attack the blood cell. Both germ and blood cell lose energy/health when fighting. When the player completed a particular level can get an augmented reality experience - by viewing internal organs of the human body. Each player details and the performance will be shown as a dashboard.

Game design and gameplay will be supposed to become an educational value added one as well as joyful. Because the game should be enjoyable to make it popularize among the kids. Some of the processes inside the human body will be embedded as game challenges in a joyful manner. As a technology Augmented Reality will be used for a small part of the application.

2.1.1 Game Progression

The player can gain score by running and takings pickups, based on the score AR component and tutorial will enable. Gradually increasing speed challenge the player.

2.1.2 Mission/challenge Structure

- Randomly generated obstacles with dead zone
- Jumping to collect pickups and avoid an obstacle.
- Swipe left, right and sliding to avoid an obstacle.
- Kill the enemies by shooting.
- Player health gradually decreases when contact with enemies.

2.1.3 Objectives

- Use mobile game addiction in an effective way.
- Introduce new technologies.
- Find the capabilities of game-based learning.

2.1.4 Play Flow

Tap to start running infinitely, the player can swipe right, left, up, and down on the mobile screen to change character's action. A single tap on the screen will make the player shooting to enemies. Collecting pickups and avoiding obstacle while running through the platform bit challenge to the

player. Base on the score AR level will be enabled. Player also participate in internal quiz session after viewing the internal organs in the AR level.

2.2 Mechanics

2.2.1 Physics

To have convincing physical behavior, an object in a game must accelerate correctly and be affected by the collision, gravity, and other forces. Unity's built-in physics Engine provide components that handle the physical simulation for developers [1].

2.2.2 Movement in the game

A player running forward within z-axis. Game assets (game floor, background object, obstacle, and pickups) have to generate infinitely along with the player's transform.

2.2.3 Objects

All background assets should be saved as prefab and instantiate or assign them when they need inside the game scene. Obstacles, obstacle spawners, and pickups can be created as different kinds of segments and store them in a prefab folder. Segments should be spawned randomly, infinitely along with the player's position.

2.2.4 Actions

UI buttons are basically using for screen navigation inside the game. Toggle buttons use for sound and language settings. User can simply tap on the screen to start the game. Player characters animation state will depend on the user's action (swipe left, right, up and down) inside the game.

2.2.5 Combat

Blood cell character should able to shoot the germs and kill them. Germ characters always run towards the blood cell because they wanted to inflict blood cell and destroy. Enemy characters' AI set its target as a player character. When blood cell and a germ interact with other both health are gradually loose. After reaching zero health, death animation will play relevant to dying character.

2.2.6 Screen Flow

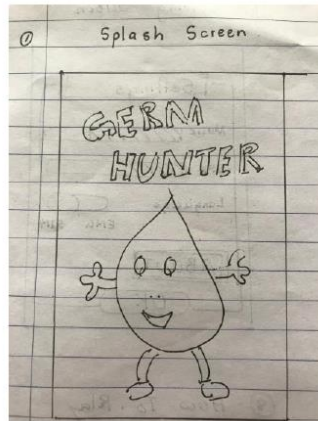


Figure 2.1: Splash Screen

Splash is the first screen that displays when the user clicks on the app icon.

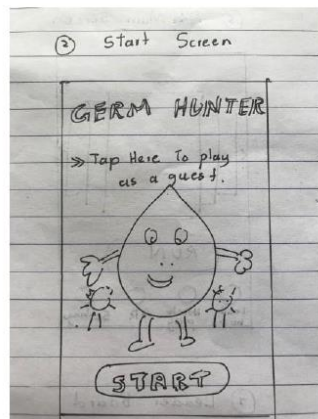


Figure 2.2: Start Screen

Splash screen automatically direct to the Start screen. If a player wants to play the game without login to the application he/she can choose to play as a guest. Otherwise, the player can log in to the app clicks on the start button.

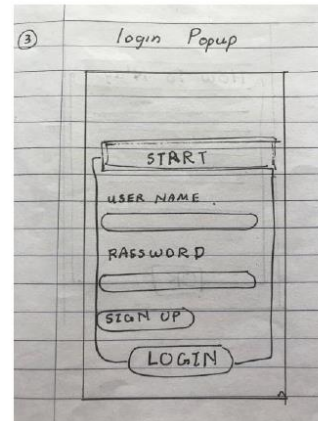


Figure 2.3: Login Popup

If a player already has an account he/she can use his/her username and password for logging the system. If not player has to create an account by clicking the sign up button.



Figure 2.4: Register Popup

The player can create an account by filling the form using his/her information and log-in to the application.

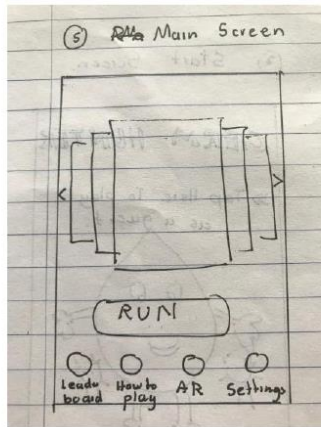


Figure 2.5: Main Screen

After the player login to the system, it will direct to the Main screen. It has an image view which will contain information related to the human body. Within the main screen, the player can direct to Leader Board, Settings, AR Component, How to Play section.

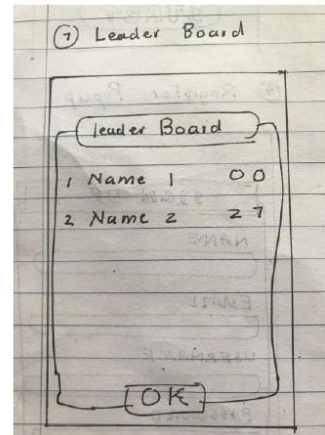


Figure 2.7: Leader Board

Leader Board will display performance of the logged players of this application.

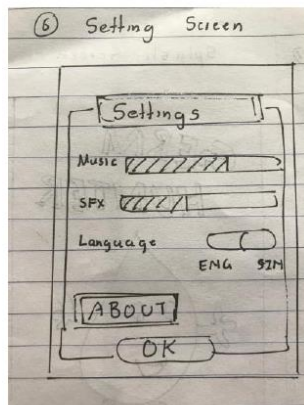


Figure 2.6: Settings Screen

The player can change the background music and sound effects in the Settings screen. As well as the player can select the language.

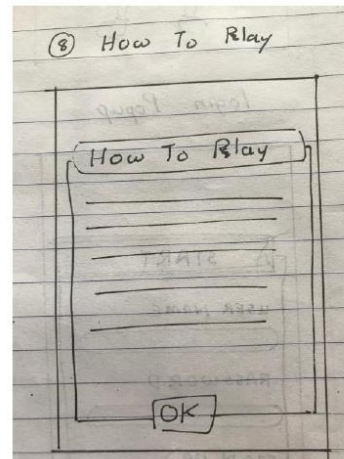


Figure 2.8: How to Play Screen

How to play screen will display instruction to the player.



Figure 2.9: Game Start Screen

When the player clicks on the Run button in the Main screen he/she will be directed to this screen. Bottom left-hand corner of the screen will show the last hi-score the game. When tap on this screen will navigate to the game.



Figure 2.11: Game Over Screen

When the player character is dead game over screen will be activated. Score and the pickup count will display on the screen. The player can replay the game from the beginning by clicking the replay button.

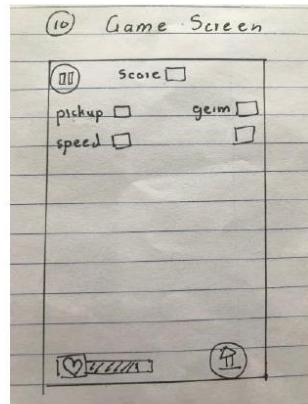


Figure 2.10: Game Screen

The game screen shows player main score, pickup count, speed multiplier, germ count and health of the player. Pause and Home button also display in the Game screen.

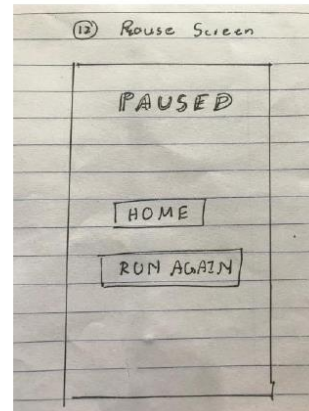


Figure 2.12: Pause Screen

Pause screen will be activated when the player clicks on the pause button on the game screen.

2.3 Game Options

The language of the Germ Hunter can be changed independently. The player can set the language in setting screen after he/she login to the application. By clicking on the language toggle button player can select the language as Sinhala or English. The default language is English.

The player can find the sound option in the settings screen. According to the necessity of the player, can mute the sound effects and game background sound.

2.4 Replaying and Saving

When a player is killed by hitting an obstacle or reducing health, game over the state will be enabled. The player can restart the game at the beginning. Score and the pickups points that are gained by the player will be displayed on the game over screen.

If existing hi-score is lower than the player current score, it will be saved in player preferences as new hi-score. Player hi-score will display on the bottom left-hand side of the game start screen.

3 The story, Setting, and Character

3.1 Story and Narrative

Player has to play the role of a Blood Cell which is running through the vein.

The gameplay consists of collecting different varieties of power boosters, avoiding obstacles and hostile creatures all the while running through the fantasy world.

Blood cell has to fight with the germs while running through the blood vein. It has superpowers and can use enzyme boost gun to destroy the germs. Germs also can attack the blood cell. Both germ and blood cell lose energy/health when fighting.

The player can gain his/her energy by destroying blood clots and cholesterol barriers inside the blood vein. The process inside the human body will be designed as game levels (Example: When the player running through the lungs he has to face the process of oxygenate/de-oxygenate.).

3.2 Game World

3.2.1 General look and feel of the world

The high-level idea is game should look like a cartoonish way of inside a human vein.

3.3 Characters

Each character should include the back story, personality, appearance, animations, abilities, relevance to the story and relationship to other characters

3.3.1 Player Character – Blood Cell

Player has played the role of a blood cell. It will be a cartoonish 3D model. Player character's animation state will be changed according to the user input. The player should be able to be in an idle, running, jump and slide state. According to the game, the blood cell should be able to fight with the germs and survive in order to win the game. The blood cell should be able to shoot the germs and kill them by using his enzyme boost gun. As well, the player should be able to survive from the barriers (obstacle – according to the game story, barriers mean cholesterol deposit inside the blood vein) when he is running through the blood vein. Germs also can hurt the blood cell. That will cause for decreasing player health.

3.3.2 Enemy Characters – Germs

Germs are active opponents of the game. Germ characters also use cartoonish 3D models. Germs attach with an enemy AI component called NavMesh Agent. So germs will always follow and pathfind towards the blood cell. Germs will be randomly generated in spawn points. When a germ gets shot and dies, a dead animation will be played and it will sink through the game floor.

4 Levels

4.1 Levels

In the main game level, the player has to run on a platform avoiding obstacles and collecting pickups. The platform repeatedly follows the player's position. Background and other game assets also repeatedly generate towards the z-axis of the game scene according to the player's translate. Because of the player's speed modifier, the game difficulty level increases over time. Enemies always move towards the player character and try to harm the player. The player can shoot the enemies and kill them. As well as the player can collect the pickups. Player score, pickups and health level display on the game GUI.

4.2 AR level

AR level will enable based on the player's score. If the player's current score exceeds the lowest score that will need to enable, the player can view the internal human organs with the help of AR technology by using the app icon as an image target.

4.3 Tutorial Level

The tutorial level also enables the base on the player's score. When a player is able to enable particular human organs to view in AR, the tutorial questions which relate to that organ will be enabled. Answering those tutorial question player can check his/her knowledge regarding particular organ.

5 Interface

5.1 Visual System

Germ Hunter HUD will display the current score, pickup count, germ count, player speed modifier and player health. Game score will calculate a combination of player running distance, pickup, and germ count.

Game scene camera model should be perspective. The camera will always look at a player and follow the player with an offset value.

5.2 Control System

The game is designed for mobile devices. All controls will be point and click on a touch screen. But unity editor controls also be included for the testing purposes. Swipe left, right, up and down on the mobile touch screen will control the player action. Button clicks control the screen navigation, sounds, and language settings.

5.3 Audio, music, sound effects

Sound Effects

- Enemy Attack sound
- Enemy hit sound
- Player shooting sound
- Button click
- The player/Enemy death sound
- Collecting pickups

Background Music

Background music for the game scene.

6 Artificial Intelligence

6.1 Opponent and Enemy AI

There is an active opponent that plays against the game player. Germ characters play as active opponents of the game. Enemy characters will be attached to a nav-mesh agent which follows the Player by the shortest path. And sooner they contact with player's trigger area player's health goes down. Enemies follow the player through the static background assets.

6.2 Support AI

6.2.1 Pathfinding

The Unity navigation system allows developers to create characters that can intelligently move around the game world, using navigation meshes that are created automatically from game scene geometry [2]. Unity NavMesh system consists of several pieces.

NavMesh

NavMesh(Navigation Mesh) is a data structure which describes the walkable surfaces of the game world and allows to find a path from one walkable location to another in the game world. The data structure is built, or baked, automatically from level geometry.

NavMesh Agent

This component helps to create characters which avoid each other while moving towards their goal. Agents reason about the game world using the NavMesh and they know how to avoid each other as well as moving obstacles.

Building a NavMesh

The process of creating a NavMesh from the level geometry is called NavMesh Baking. The process collects the Render Meshes and backgrounds of all Game Objects which are marked as Navigation Static and then processes them to create a navigation mesh that approximates the walkable surfaces of the level.

Creating a NavMesh Agent

Once you have a NavMesh baked for your level it is time to create a character which can navigate the scene. The NavMesh Agent component handles both the pathfinding and the movement control of a character.

In script going to attach for enemy movement, need to get a reference to the NavMesh Agent component and then to set the agent in motion, just need to assign a position to its destination property.

6.2.2 Collision Detection

Collision components should be attached with the tag. When a game object (e.g.: player) interact with an obstacle or a pickup, player attaches script may compare the collision tag when collision enters and perform relevant action to that tag.

7 Technical

7.1 Target Hardware

- Android Devices (1st version deploy only for Android devices, further versions planning to deploy both Android and iOS devices)

7.2 Development hardware and software

Software

- Unity 3D Game Engine (Version 2018.3.9f)– for game developing
- Visual Studio 2017 – for scripting
- Autodesk Maya – for 3D modeling and texturing
- Mixamo – for character animating
- Adobe Illustrator and Photoshop CC – for UI designing

Hardware

- Laptop – Processor : Intel(R) Core(TM) i5-3337U CPU, 1.8 GHz, RAM : 8.00 GB
- Android Phone – Samsung J7 (for testing)

7.3 Network requirements

Server

The game requires a backend server. The server has to handle user registration, login, leader board, performance. The server should be built using a rest API to allow access from multiple types of devices and allows a high degree of compatibility.

To access API services need an internet connection.

8 Game Art

Characters are one of the key assets in the game. Both enemy and the player character will be modeled inside Autodesk Maya. And can apply predefined animation pack to those characters using Mixamo Open Source software.

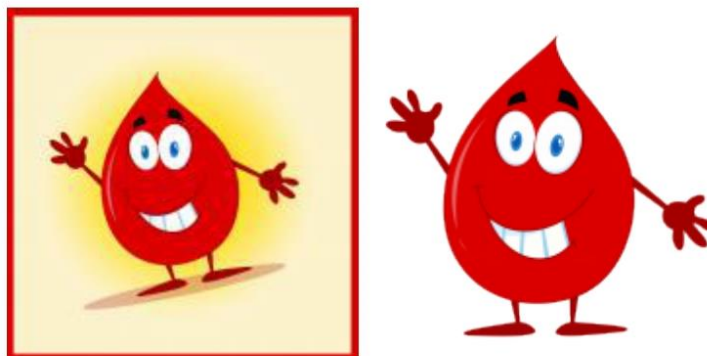
Other background assets – obstacle and pickups also have to model in Maya. Textures can be applied to those 3D models within the Maya or Unity editor.

As obstacles have to build small pieces (blocks, long blocks, slide, jump, etc.).

9 Basic Screen Design Guide Base on the Paper

Prototype

App Icons

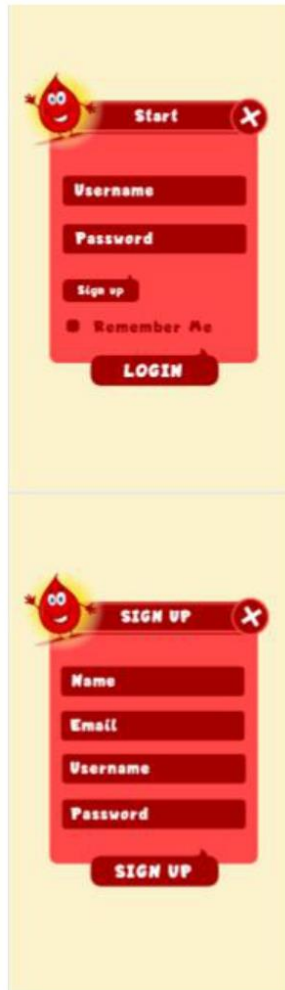


17

Primary Screen Guide







References

[1] Technologies, U. (2019). *Unity - Manual: Navigation System in Unity*. [online] Docs.unity3d.com. Available at: <https://docs.unity3d.com/Manual/nav-NavigationSystem.html> [Accessed 2 September 2018].

[2] Technologies, U. (2019). *Unity - Manual: Physics*. [online] Docs.unity3d.com. Available at: <https://docs.unity3d.com/Manual/PhysicsSection.html> [Accessed 2 September 2018].

Appendix B - Evaluation & Test Results

The questionnaire used to get user evaluation result and charts created a base on their results is mentioned below. Following questionnaire has two parts, part one for the youngsters part two for the parents as mention chapter 5.4.

Germ Hunter - Educational Content Embed Mobile Runner Game with Augmented Reality

* Required

Questionnaire for players (Youngsters)

Questionnaire for youngsters who plays the Germ Hunter

1. Age Group *

Mark only one oval.

- Year 8 - 10
 Year 10 - 12
 Year 12 - 14

2. Gender *

Mark only one oval.

- Male
 Female

3. What is your grade *

Mark only one oval.

- Grade 4
 Grade 5
 Grade 6
 Grade 7
 Grade 8
 Grade 9

4. Player experience *

Mark only one oval.

- Novice
 Medium
 Expert

Figure B.1: Questionnaire

5. Have you play mobile game before ? *

Mark only one oval.

- Do not use mobile phone
- Do not play mobile games
- Daily
- Sometimes

6. How often do you play mobile games? *

Mark only one oval.

- 0 - 1 hour
- 2 hours
- 3 hours
- 4 hours
- 5 or more hours

7. What types of games did you play before? *

Check all that apply.

- Action
- Adventure
- Simulation
- Sports
- Strategy/Puzzle
- Educational

8. Why do you play the games you checked above ? *

Check all that apply.

- I like the graphics/realism
- relaxation/recreation/escapism
- It challenges my mind
- It's such a great feeling to master or finish a game
- I'll play anything when I'm bored
- Other

9. Do you enjoy the playing Germ Hunter ? *

Mark only one oval.

- Yes
- No

Figure B.2: Questionnaire

10. Do you think that Germ Hunter has educational content ? *

Mark only one oval.

- Yes
- No
- Maybe
- Other: _____

11. Have you learned anything from playing Germ Hunter ? *

Mark only one oval.

- Yes
- No
- Other: _____

12. What do you most like about Germ Hunter? *

Check all that apply.

- Endless running
- Graphics
- Fast
- Addicting

13. What do you most dislike about Germ Hunter? *

Check all that apply.

- It takes up too much time
- It's frustrating
- It's boring
- My friends don't play
- Too many rules to learn

14. Which do you rate higher on a Germ Hunter game? *

Check all that apply.

- Graphics over game play
- Game play over graphics
- Educational content
- New technology Features
- Other: _____

15. How does playing games tend to make you feel? *

Mark only one oval.

- Feel pretty good
- Get irritated
- Other: _____

Figure B.3: Questionnaire

16. What is your opinion of Germ Hunter? *

Mark only one oval.

- It's frustrating it's boring
- Too many rules to learn it's pointless
- Easy and enjoyable to play
- It is good to add more educational content

17. What did your parents think of video games? *

Mark only one oval.

- They think it is a good way to keep us kids occupied.
- They don't allow us to play
- They think it is addicting

Questionnaire for parents

18. Have your child allow to play video/mobile game before? *

Mark only one oval.

- Yes
- No

19. How much time does your child spend on school work / homework? *

Mark only one oval.

- 0-1 hour
- 1-2 hour
- 2-3 hour

20. The type of game my child primarily plays is: *

Check all that apply.

- Action
- Sports
- Puzzle
- Racing
- Educational

21. On an average weekday, my child plays video games for: *

Mark only one oval.

- 1-2 hour
- 2-3 hour
- 3-4 hour
- 4-5 hour

Figure B.4: Questionnaire

22. My child is permitted to play video games before homework is completed: *

(Mark only one oval.)

- Never or rarely.
- Occasionally.
- Frequently.
- Almost always.

23. Do you think that it is easy way to learn educational content through a game? *

(Mark only one oval.)

- It is a good way to teach complex and large theory content easily
- Visual based learning is more effective than text based learning
- It is good way to teach something inside a game because they love to play games.
- It is a not a good way
- Other: _____

24. Do you believe it is possible to make a game that is educational but still hold a child's attention? If possible, explain how you think this might be accomplished.

25. What is your opinion regarding game based learning

Figure B.5: Questionnaire

Followings charts were generated based on the results of the above questionnaire.

Asked a couple of questions to get basic details about the player which are important to analyze player performance such as age group, gender, grade and game playing experience. Following figure 6-10 summarize above basic details of the target audience.

Age Group
16 responses

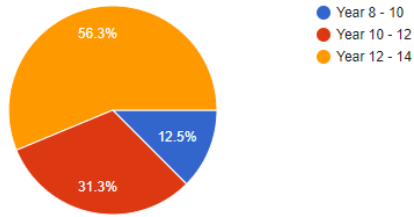


Figure B.6: Age Group

Gender
16 responses

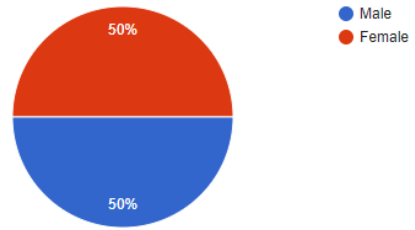


Figure B.7: Gender

What is your grade
16 responses

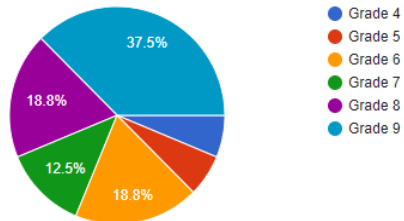


Figure B.8: Grade of the Players

Player experience
16 responses

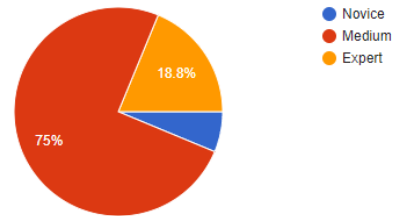


Figure B.9: Player Experience

Figure 10 - 12 are summarizing players' previous of mobile gaming

Have you play mobile game before ?
16 responses

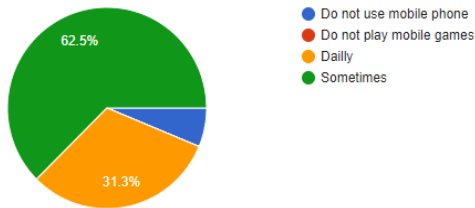


Figure B.10: Grade of the Players

How often do you play mobile games?
16 responses

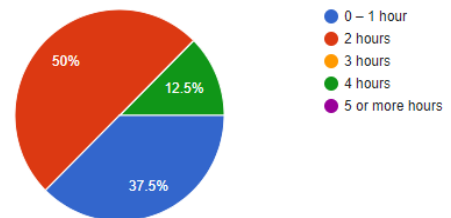


Figure B.11: Player Experience

What types of games did you play before?

16 responses

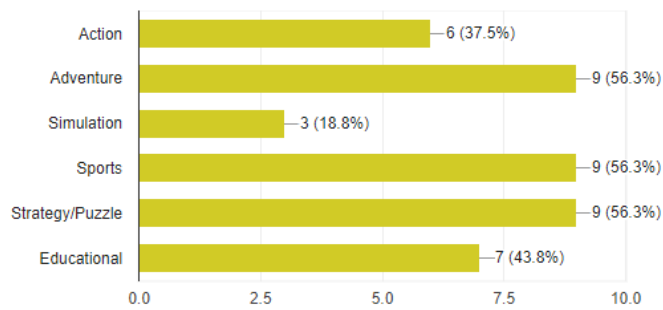


Figure B.12: Player Experience

Below charts are showing player experience on Germ Hunter. As shown below in figure A.13, all the players enjoy playing the Germ Hunter.

Do you enjoy the playing Germ Hunter ?

16 responses



Figure B.13: Player Experience

Most of the respondent(62.5%) evaluated Germ Hunter as easy and enjoyable to play. 18.8% suggested need more educational content. (Shown in figure A.13)

What is your opinion of Germ Hunter?

16 responses

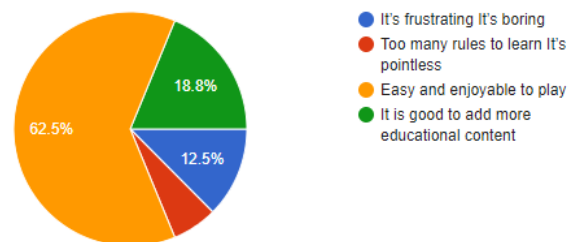


Figure B.14: Player opinion about Germ Hunter

93.8% of players learn something from the game playing according to the below summarize chart. (Shown in Figure A.15)

Have you learned anything from playing Germ Hunter ?
16 responses

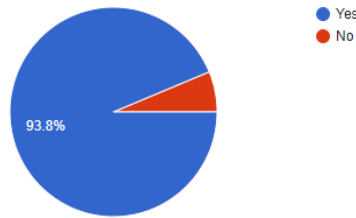


Figure B.15: Player Experience

According to Figure A.16 - 68.8% of players like graphics of the Germ Hunter. 31.3% of players like the endless running genre. 37.5% responded as addicting.

What do you most like about Germ Hunter?

16 responses

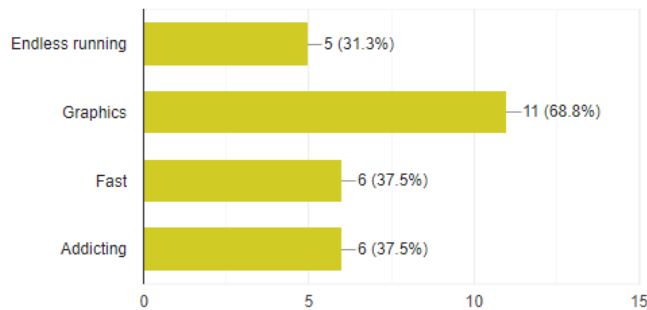


Figure B.16: Player Experience

62.5% respondent voted educational content over other features of the game like graphics and gameplay. 37.5% voted on new technology feature of the game. (Shown in Figure A.17)

Which do you rate higher on a Germ Hunter game?

16 responses

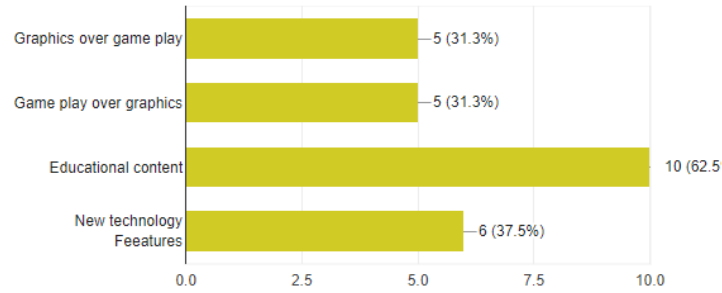


Figure B.17: Highest rate component

Part 2 of the questionnaire focusing on parents' awareness of children game playing activities. At first, tried to figure out that parents allow playing the mobile game before. The result is shown in Figure A.18.

Have your child allow to play video/mobile game before

16 responses

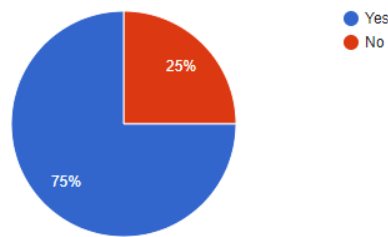


Figure B.18: Parent Experience

Most of the parents give permission occasionally to play mobile games before completing their school homework.

My child is permitted to play video games before homework is completed:

16 responses

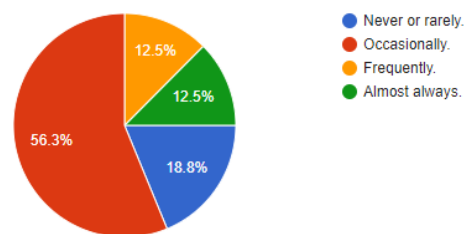


Figure B.19: Parent Experience

62.5% of parents agreed that visual-based learning is more effective. (Shown in Figure A.20)

Do you think that it is easy way to learn educational content through a game?

16 responses

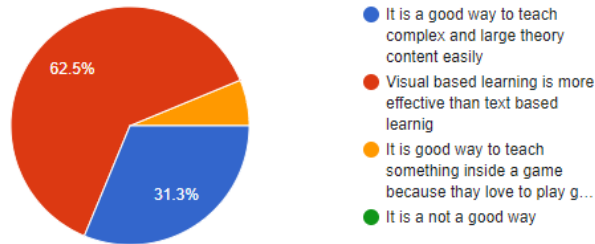


Figure B.20: Parent Experience

Figure A.21 and Figure A.22 shown the answers to the open-ended questions at the end of the questionnaire.

Do you believe it is possible to make a game that is educational but still hold a child's attention? If possible, explain how you think this might be accomplished.

8 responses

Possible if the educational game have interesting game play with attractive graphics
Yes it is possible because children like and remember graphics learning more faster then text book reading.
Good graphics & cool animations.
yes
game challengers are provide to children so they will be pay attention to it
Yes.Educational game can be made with their hero characters.
Yes
Better graphics with attractive content

Figure B.21: Open-ended question

What is your opinion regarding game based learning

9 responses

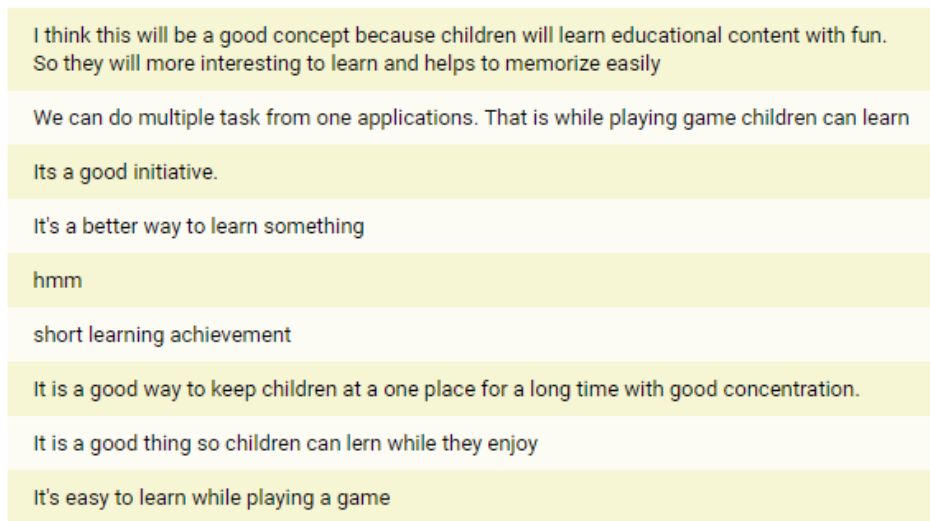


Figure B.22: Open-ended question

Appendix C - Test Plan & Test Results

Test Case for the Login Function.

Table C.1: A Test case for login

Test Case Name:	Login Function			Test Case Number	Login - 1A	
Brief Description	Login - Positive Test Case					
Pre-Conditions	Open Germ Hunter application User must be registered already / A valid user account Internet connection					
Step	Action	Input Test Data	Steps to be Executed	Expected Results	Actual Results	Pass / Fail
1	Test if the user is able to login successfully	correct username, correct password	1)Enter input(correct)username and password on the respective fields 2)click submit/login	User must successfully log in to the application , redirect to the main screen	As Expected	Pass
2	Test if unregistered users are not able to login to the site	incorrect username, incorrect password	1)Enter input(incorrect)username and password on the respective fields 2)click submit/login	The proper error must be displayed and prompt to enter login again	As Expected	Pass
3	Test with a valid username and empty password such that	a valid username and empty password	1)enter the valid username in the user id and enter no password in	The proper error must be displayed and prompt to enter	As Expected	Pass

	login must get failed		the password field	login again		
4	Test with empty username and valid password such that login must get failed	empty username and valid password	1)leave the username empty in the user id and enter a valid user's password in the password field	The proper error must be displayed and prompt to enter login again	As Expected	Pass
5	Test with empty username and empty password and check if login fails	-	1)Enter nothing in the mail id and password field 2)click submit button	The proper error must be displayed and prompt to enter login again	As Expected	Pass
6	Check of the password is masked on the screen i.e., the password must be in bullets or asterisks	some password(can be a registered/unregistered)	1) Enter the password field with some characters	The password field should display the characters in asterisks or bullets such that the password is not visible on the screen	As Expected	Pass

Test Case for the Register Function.

Table C.2: A Test case for register

Test Case Name:	Register Function			Test Case Number	Register - 1A	
Brief Description	Register - Positive Test Case					
Pre-Conditions	Open Germ Hunter application Internet connection					
Step	Action	Input Test Data	Steps to be Executed	Expected Results	Actual Results	Pass / Fail
1	Test if the user is able to register successfully	Correct field data	1) Fill all the field correctly 2)Click / submit register	User must successfully register and, redirect to the login screen	As Expected	Pass
2	Test with empty fields and check if register fails	-	1)Enter nothing in the fields 2)click submit button	The proper error must be displayed and prompt to enter Register again	As Expected	Pass