AN INTERACTIVE SERIOUS GAME FOR DEMENTIA PREVENTION

BY

YEW WEI HONG

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfillment of the requirements

for the degree of

BACHELOR OF COMPUTER SCIENCE (HONOURS)

Faculty of Information and Communication Technology

(Kampar Campus)

JAN 2022

UNIVERSITI TUNKU ABDUL RAHMAN

REPORT STATUS DECLARATION FORM

Title: ______An Interactive Serious Game for Dementia Prevention________

____

____

Academic Session: ____JAN 2022____

I ________________YEW WEI HONG________________________

(CAPITAL LETTER)

declare that I allow this Final Year Project Report to be kept in
Universiti Tunku Abdul Rahman Library subject to the regulations as follows:

1. The dissertation is a property of the Library.
2. The Library is allowed to make copies of this dissertation for academic purposes.

Verified by,

_________________________ (Author's signature)

_________________________ (Supervisor's signature)

Address:

___08-TINGKAT 6, (C),_____
___LORONG SRI PINANG 4_
___TAMAN SRI PINANG____
___13020, BW, PENANG____

______Ts. Saw Seow Hui_______
Supervisor's name

Date: _____2/4/2022________________

Date: _____21/4/2022_____

Universiti Tunku Abdul Rahman			
Form Title : **Sample of Submission Sheet for FYP/Dissertation/Thesis**			
Form Number: **FM-IAD-004**	Rev No.: **0**	Effective Date: **21 JUNE 2011**	Page No.: **1 of 1**

FACULTY OF _INFORMATION AND COMMUNICATION TECHNOLOGY_

UNIVERSITI TUNKU ABDUL RAHMAN

Date: __2/4/2022__

SUBMISSION OF FINAL YEAR PROJECT /DISSERTATION/THESIS

It is hereby certified that ______***YEW WEI HONG*** _____________ (ID No: __***18ACB04417***___) has completed this final year project entitled "_____An Interactive Serious Game for Dementia Prevention _" under the supervision of _Ts. Saw Seow Hui_____ (Supervisor) from the Department of ______________________, Faculty of ____Information and Communication Technology___.

I understand that University will upload softcopy of my final year project in pdf format into UTAR Institutional Repository, which may be made accessible to UTAR community and public.

Yours truly,

____

Yew Wei Hong

*Delete whichever not applicable

DECLARATION OF ORIGINALITY

I declare that this report entitled "**AN INTERACTIVE SERIOUS GAME FOR DEMENTIA PREVENTION**" is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award.

Signature : _________________________

Name : ___Yew Wei Hong_________

Date : ______2/4/2022___________

ACKNOWLEDGEMENTS

I would like to express my gratitude and appreciation to my supervisors, Ts. Saw Seow Hui who provides her invaluable suggestions, guidance and comments throughout the final year project. The ideas given by her every supervisee meeting session had led me to towards the successful completion of this project. Ms. Saw is very dedicated in helping me as her supervisee in the project. She would correct me when I was wrong, guide me when I was lost and motivate me to work harder.

Also, I wish to thank my parents and my family for their continuous love, both moral and emotional support and continuous encouragement throughout the completion of the entire project.

ABSTRACT

In the recent years, the situation of rapidly aging population growth in most parts of the world creates a worrying situation. There is also a rise in age-related diseases associated with cognitive deficits, such as dementia. Normal cognitive status plays an essential role in controlling individuals' thinking and action to carry out normal daily activities. A healthy cognitive status could lower the risk of an individuals in getting cognitive impairments. A serious game related with game development. The serious game is a game with other purposes besides entertainment such as education, healthcare, and training. The main motivation of the project is to develop a serious game that could assess and train the potential risk factors that lead to cognitive impairments such as dementia. The serious game for dementia prevention can prevent or slow down the cognitive decline in an individual. The project aims to develop a serious game application for dementia prevention, create awareness among the public about dementia, and provide a cost-free serious game that could be played by elderly to prevent dementia. The contribution of this project will be creating a Malaysia-themed serious game for dementia prevention which is cost-free and available for anyone who is interested. The serious game will train and assess the cognitive functionalities related to dementia using test based on Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA). The project is expected to help in lowering the growth of dementia and increase the awareness among the public about dementia using a cost-free serious game for dementia prevention.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

UI	User Interface
MoCA	Montreal Cognitive Assessment
MMSE	Mini-Mental State Examination
SMMSE	Standardised Mini-Mental State Examination
RNG	Random number generator
RT	Response time
QR	Quick response
NFC	Near-field communication

Chapter 1

Introduction

1.1 Problem Statement and Motivation

Ageing is an integral process that will continue throughout our life. When people aged, the cognitive function might deteriorate leading to several cognitive impairments. The problem with cognitive impairment diseases is that most type of dementia is not curable. Fortunately, dementia can be prevented to a certain extend. According to the Alzheimer society [1], brain exercise such as puzzles and board games that can keep an individual's mind active could reduce the risk of getting dementia. Next, doctors and researchers are still researching on how the dementia condition develops, so it would be hard to find a clinically proven effective solution in assessing dementia. Another problem is that most serious games for dementia prevention that are available in the market runs only on mobile platform and requires users to pay an expensive amount of monthly subscription. These serious games have a complex UI that may not be suitable and comfortable for elderly. Lastly, the problem is that most Malaysian perceive Alzheimer disease or dementia as a norm of ageing. With this being said, Malaysian are keen to not do diagnosis test or seek for medical advice from health professionals.

The motivation of the project is to develop first few Malaysia-themed serious game for dementia prevention. The serious game will be simple and easy to understand. The serious game for dementia will be totally free of charge for everyone to lower the user's burden. The project also aims to propose an efficient assessment test to assess dementia of an individual based on clinical proven cognitive assessment. The serious games that are available in the project will mainly assess the cognitive abilities of the player. These serious games are separated into 4 categories namely problem solving, speed, attention and memory aiming to help the player to prevent and assess dementia. Lastly, the Malaysia-themed serious games could help Malaysian to be more exposed to dementia, educating and increase their awareness towards the severity of the disease. This serious game will assist the elderly to prevent and slow down dementia symptoms or recover from mild dementia symptoms. [2]

1.2 Objectives

The system that the project aims to deliver is a serious game for dementia prevention. The system will contain different groups of serious games according to their respective characteristic. The project objectives are as follow:

I. To develop a Malaysia themed serious game for dementia prevention.
   a. The serious game will be Malaysia themed.
   b. The serious game is able to train the cognitive abilities.

II. To develop a cognitive scoring matrix for each game to assess dementia.

III. To provide a cost-free serious game for the elderly to prevent dementia.

IV. To develop a simple serious game for dementia prevention that runs on computer.

V. To develop a cloud-connected serious game.

To develop a Malaysia themed serious game for dementia prevention

This project aims to develop a serious game for dementia prevention with a Malaysia theme. The purpose of develop the serious game based on Malaysia because there is a less serious game for dementia prevention in Malaysia. The serious game also can help to increase awareness of Malaysians and change their perspective on how dementia can be prevented. Next, the serious game intended to prevent dementia that is not curable based on proven medical statement. The serious game developed can train player's cognitive functions and at the same time assessing them. The system can train the player's cognitive function based on 4 categories – speed, attention, memory and problem solving.

To develop a cognitive scoring matrix to assess dementia

This project aims to develop a cognitive scoring matrix to assess dementia based on 2 existing assessment test which is Mini-Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA). The serious game scoring matrix will be tailored based on the weightage presented by the existing assessment tests for each cognitive function categories. A total cognitive score will be calculated based on the cognitive function categories.

To provide a cost-free serious game for the elderly to prevent dementia

The system developed in the project is also cost-free. Many existing serious games for dementia prevention available in the market require expensive monthly subscription. Our serious game provides complete features that could also assess and prevent dementia for free to lower the burden of the player.

To develop a simple serious game for dementia prevention that runs on computer

Most serious game for dementia prevention available only runs as mobile application and have complex user interface (UI) which is not friendly to the users. Smart phones are considered new technologies for the elderly. The elderly needs to learn how to operate a smart phone before they can play the game. The project develops a simple serious game that runs on the computer so that elderly would not find any difficulties installing and playing the serious game. The simple user interface (UI) of the serious game can also reduce the complexity that could make the elderly confuse.

To develop a cloud-connected serious game

The computer-based characteristic of the serious game makes it difficult for users to access to the game as it is not mobile. The issue had been solved by enable the users to store their credentials and game-related data into the cloud. Users can access their account using their login credentials given that they have a computer that have the game installed. The data being stored in the cloud can be accessed by computer with computer access.

Objectives	Problems to be solved
Develop a Malaysia themed serious game for dementia prevention.	- Increase awareness and change the perspective about dementia among Malaysians. - Most dementia could not be cured but preventable.
Develop a scoring matrix to assess dementia.	- Dementia is hard to assess.
Cost-free serious game for elderly to prevent dementia.	- Most serious games related to dementia available requires expensive monthly subscription.
Develop a simple serious game for dementia prevention that runs on computer.	- Complex UI that may be difficult for elderly. - Most elderly may not familiar with smartphone controls.
Develop cloud connected serious game	- Computers are not mobile enough.

Table 1.1: Project objectives and problems

1.3 Project Scope and Direction

The deliverable of the project will be a serious game for dementia prevention developed using Unity3D. The main functions of the application are to provide games that can train player's cognitive function, login functions, data storage in cloud and leaderboard function.

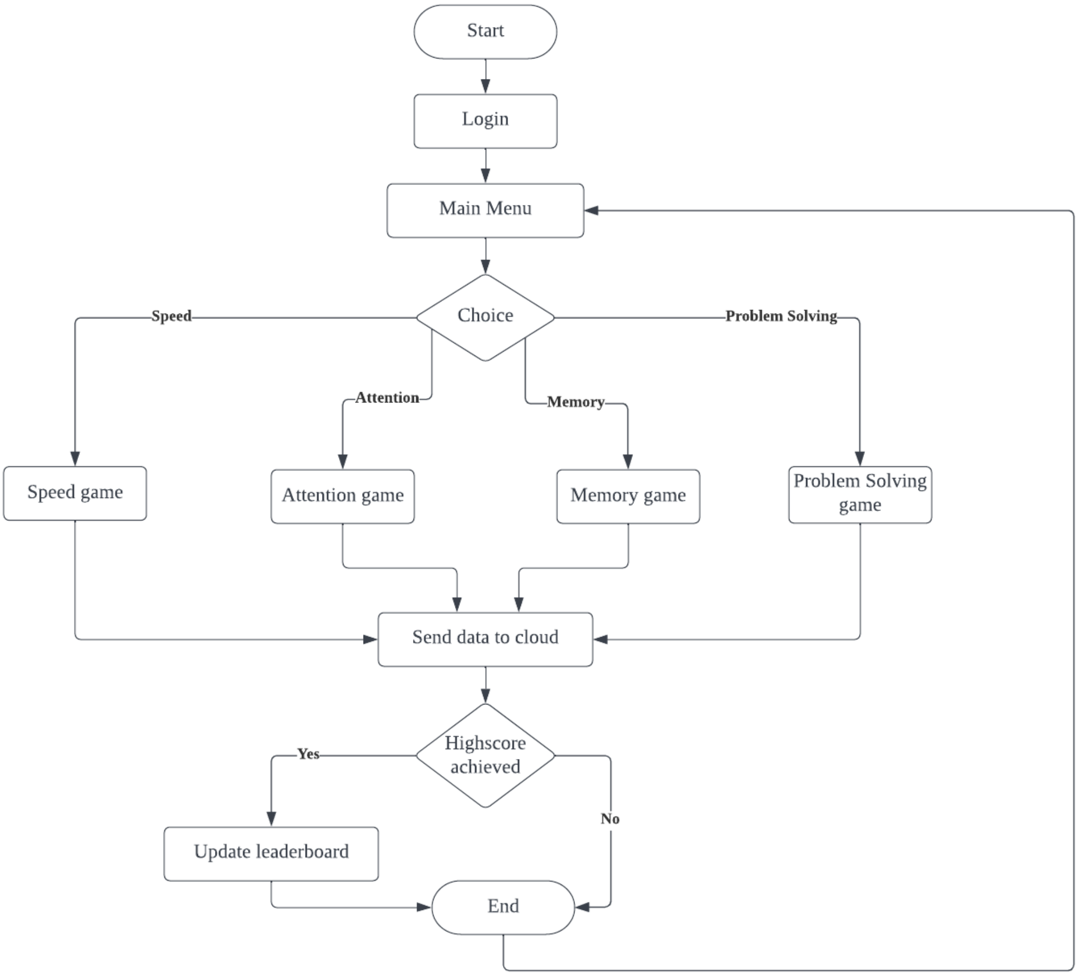


Figure 1.1: Flowchart for the game flow

First, the user will be prompted to register an account and that their credentials and related information can be stored in the online cloud. Then, the users can login with the email and password used for account registration. After login, the user can start to play the game by choosing the types of game they wanted to play. The serious games will be separated into 4 different groups which are speed, memory, attention and problem solving. Upon choosing a game to play, the user will be able to enter to the game. After the user complete the serious game, their new score will be uploaded and saved in the cloud. If the user played well and score high score, their score will be updated into the leaderboard. The leaderboard will be a community leaderboard where it includes score from all players. The user can then choose whether to replay the game, choose another game, or exit to main menu.

The cognitive score of the player will be separated into different categories according to the type of games they played. The scoring matrix will be based on different criteria such as scores obtained, time taken to complete. For example, the game "CatchFallingObject" are grouped in category of "speed", so the user's performance will be calculated into the "speed" group. An overall cognitive score will be calculated based on the cognitive scores in different categories. Both Mini-Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA) will be used as reference for the project scoring mechanism. The score for each category will be determined by the weightage hold in both the assessment test. Each cognitive function categories will be accessed and given a score. An overall cognitive score will be calculated based on how well the players perform in different categories. The players can assess their cognitive scores and obtain knowledge about how well they performed in the game and their degree of cognitive functionalities.

1.4 Contributions

The contributions of this project are to provide a cost-free serious game for dementia that could benefits the elderly in preventing and assessing dementia. The serious game could help those who hoped to assess their cognitive scores and at the same does not have the ability to afford expensive monthly subscription cost.

Next, the serious game for dementia can also increase the awareness about dementia about the public especially Malaysia. The serious game could help Malaysians to put more attention into how dementia can be prevented rather than perceiving dementia as a normal process of ageing. Moreover, the data and information that is collected through the serious game such as cognitive scores could be a valuable source for researchers to gain insights regarding dementia.

1.5 Project Background Information

The project mainly focuses on two fields which is medical field related to dementia and serious game development.

Ageing is a process that being with life and will continue as an integral part of our life cycle. The rapid ageing in the world population is concerning as it is becoming a common phenomenon that already existed in most countries such as Korea and Japan. Due to improvements of living standards, health care, and daily nutrition, overall life expectancy has increased as fertility rates have decreased, resulting in a substantial increase in the old population. [3] The significant increase in the elderly population has raised worries about age-related disease such as dementia. According to What Is Dementia? Symptoms, Types, and Diagnosis published by the U.S. Department of Health & Human Services (2017) [4], dementia refers to the reduction of normal cognitive functioning such as reasoning, thinking, remembering, and behavioural abilities that might lead to the extent that dementia would affect one's daily activities and daily life. Progressive and irreversible loss of brain and neurone functioning have resulted from these neurodegenerative disorders. Most dementia disorders are not curable but can be diagnosed and recognised through the pattern of loss of neurone and brain function. Fortunately, dementia can be prevented to a certain extend. [3] According to National Health Service UK (2021) [5], dementia can be prevented and reduced by being physically active, eat healthily, no smoking, cut down alcohol intake, mind exercise, and health control. According to a report by Karim [6], a constant increased in the elderly population in Malaysia had occurred from 4.6% in 1957 to 5.7% in 1990. Moreover, it is also predicted that the percentage of the elderly will be increased from 6.3% in the year 2000 to 12% by the year 2030. It was reported by the Alzheimer Disease International report that the occurrence of dementia in Malaysia was 0.063% in the year of 2005 and it was predicted to increase to 0.126% in 2020 and 0.454% in 2050. According to The Alzheimer's Disease Foundation Malaysia, about 50,000 Malaysians would be diagnosed with Alzheimer's disease in 2016. [8] Malaysians are preoccupied with the stereotype that dementia illness is a natural part of ageing and that it is a sign that they are becoming old, and they do not seek medical guidance from health experts.

The dementia disease can be assessed through 2 tests which are Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment. Mini-Mental State Examination (MMSE), also known as the Standardised Mini-Mental State Examination (SMMSE) or Folstein Test, is a practical and straightforward test taken to assess the cognitive impairment of a person. The Mini-Mental State Examination (MMSE) scoring is based on multiple categories. The five categories to be tested in the Mini-Mental State Examination (MMSE) are orientation to time and place, attention and ability to solve problems, comprehension and motor skills, short-term memory, and language. However, the Mini-Mental State Examination (MMSE) is more often used to ruling out dementia than dementia diagnosis. [9] Montreal Cognitive Assessment (MoCA) is cognitive assessment similar to the Mini-Mental State Examination (MMSE). The Mini-Mental State Examination (MMSE) is used to study dementia, while Montreal Cognitive Assessment (MoCA) is better at identifying mild dementia. [10] The Montreal Cognitive Assessment (MoCA) evaluates the different cognitive abilities: orientation, short-term memory, executive function or visuospatial ability, language, animal naming, abstraction, attention, and clock drawing test. The Montreal Cognitive Assessment (MoCA) determines whether a person tested shows signs of dementia. It is shown that Montreal Cognitive Assessment (MoCA) is a reliable test or indicator for predicting dementia in a person. [11]

Serious game are emerging and has been used in many applications. Based on Kiho, Eun-Jin and Young-Suk [12], a serious game’s special purpose and medium for delivering clear themes defer serious games with other typical games that have only entertainment elements. One article by Grendel games [13] stated that serious game are designed to use the engagement and entertainment components provided when playing the game to solve problems in several areas and involve challenges and rewards. According to Fedwa L., Mohamad E. and Abdulmotaleb E.S. [14] stated that the term "Serious Game" was coined by Clark C. Abt in the 1970s. The purpose of serious game technology is to provide an innovative gaming solution to improve education for the physical and social sciences, planning and problem solving, occupational choice, and training in the industries and government sectors.

The project will be a serious game that its purpose is to help people to prevent dementia. There are already some serious games for dementia prevention available in the market such as MindMate, CognitFit and Lumosity. These serious games have shown a beneficial effect on dementia patients. It has a high level of research activity recently in diagnostic and prevention activities. McCallum and Boletsis [15] presented that the use of video games for dementia prevention is yet a worthy investigation. The games that McCallum and Boletsis [15] had reviewed include Willfit, MinWii, Brain Academy, WiiSport, and Lumosity. These games are mostly designed to slow down and prevent the progression of dementia. In addition, these games are said to improve the participant's dependencies without supervision and able to reduce the reduced stress levels by generating a relaxing mental state. Lastly, these games had also proven to help participants in their social interaction.

1.6 Report Organization

The chapter 1 Introduction will cover the background, problem statement and motivation, objectives, project scope and direction, contributions, project background information and report organization for the system "An Interactive Serious Game for Dementia Prevention".

In chapter 2, literature review from different system, articles, papers and authors are conducted. The literature review will provide a better understanding of the modules included in the serious game development. Moreover, the review can compare the weaknesses and strengths of the system review and provide an insight of the functions to be included into the system.

The serious game for dementia prevention system methodology and approach are completed in Chapter 3. The methodologies used in the project will be covered in the system design specification. The system's general development approach will be used to present an overview of how the system is developed. The chapter will include use case diagrams, use case descriptions, and activity diagrams.

The design of the system will be covered in Chapter 4. The overall system architecture, component diagram, sequence diagram, and user interface diagram will all be included in Chapter 4. The system implementation will be covered in Chapter 5. The hardware and software used in the project will be covered in this chapter. The chapter will cover the necessary setup, system flow, game mechanism, and script codes.

In chapter 6, the system evaluation and discussion will be covered. The chapter will cover module testing, challenges, and objective evaluation of the system. Chapter 7 will contain the conclusion.

CHAPTER 2

Literature Reviews

2.1 Literature Review

2.1.1 Serious Games for Dementia

The paper titled “Serious Games for Dementia” by Tiffany, Jonathan, and Mark [16] took the approach in dementia prevention by creating a serious game targeted at individuals with cognitive impairment. The serious game proposed by the authors provides common assessments that assess the executive function. The authors claim to have created a "Executive Timed Target Game," a variation on the whack-a-mole game, to measure inhibition ability in relation to overall functional ability. The paper also mentioned that executive function ability would continue to decline as people aged, having a substantial influence on functional abilities needed to do everyday tasks. Furthermore, the authors also theorize that the user’s game performance correlates with cognitive status and executive functioning measures. Moreover, the authors also proposed games such as “concentration,” “sports and news trivia,” “trail-stepping,” “Executive timed target task,” “Recognizing objects by name and function,” and “reminiscence” to assess different cognitive functionalities.

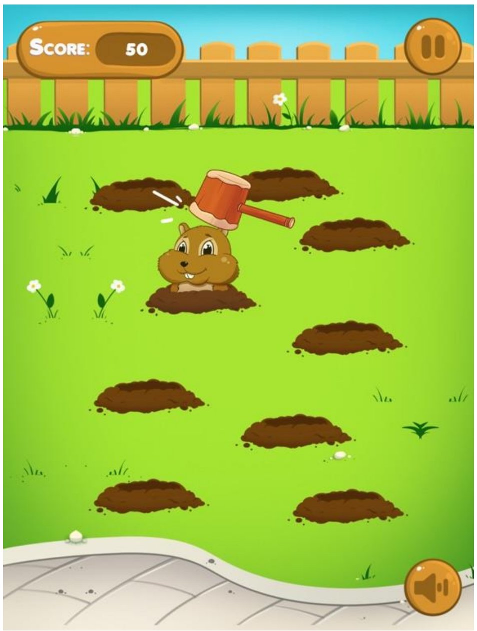


Figure 2.1: Example of Executive timed target task

Strengths

First, the strength of the proposed serious game is that the serious game is closely related to the Stroop task, which tests the inhibitory executive function. The inhibitory executive is correlated with the loss of white matter in the brain and declines as people grow old. Second, the

"Executive Timed Target Game" is tested with an older emergency patient sample utilising response time (RT) game performance, as well as cognitive assessment measures such as the Mini-Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA). The Mini-Mental State Examination (MMSE) yielded a significant outcome in 13 of 17 dementia patients. Secondly, the proposed serious game targeted different cognitive abilities that may degrade over time and cause dementia, such as short-term memory, long-term memory, switching, word/object recognition, and time/place orientation. By targeting these cognitive abilities, serious games can help individuals in different cognitive status types in non-clinical settings such as long-term care. For example, an elderly person who is struggling with word/object identification may benefit from serious games that focus on the ability. Finally, the authors show and justify different types of games that are associated with different cognitive abilities. For example, concentration games such as memory card games will help short-term memory, and trivia games such as sports and news trivia to assess a person's long-term memory. [16]

Weaknesses/Limitations

First, this paper's weakness is that it might be tough to create an enjoyable game that assesses each cognitive component according to the user's interest. For example, users are interested in improving their long-term memory, but it would be boring to play memory card games for a long time. It would cause users to lose interest in playing the game and stop playing. Another weakness of this paper is that the authors proposed using a game "Trail-Stepping" such as Dance, Dance Revolution, a trail-making approach that implements shifting or switching tasks. However, the "Trail-stepping" game trains visual attention and set-shifting, which users set on the number mat panel in the order of numbers projected on the screen. It would be difficult and expensive if everyone needs to buy a mat panel just to play the game.

2.1.2 Proposal of a Serious Game to help prevent Dementia.

The paper titled "Proposal of a Serious Game to Help Prevent Dementia" by Kiho K., Eun-Jun C., and Young-Suk L. [12] took the initiative to create a Serious Game titled "TapBrain," a therapeutic tool for the aging population in Korea. The authors also stated that their purpose is to develop a dementia prevention game that is enjoyable for everyone instead of treating dementia, requiring professional clinical trials. The proposed serious game "TapBrain" will have 17 different mini-games as the game structure. The 17 mini-games are "Finding the same shapes”, “Finding the same patterns”, “Finding instant numbers”, “Finding instant numbers”, “Counting the number of people”, “Order memorization”, “Finding words”, “Timing of taps”, “Shooting falling squares”, “The main four arithmetical operations”, “Finding the culprit”, “Finding sequences of the same cards”, “Finding rabbits”, and “Waking up hens”. Among the 17 mini-games, 13 mini-games are brain exercise stimulation games, and the other four are played to induce physical activity. The 17 different mini-games are divided into six categories: brain exercise stimulation and physical activities such as attention, memory, response, decision, problem-solving, hand motion, and upper body movement.

Strengths

First, this paper's strength is that the authors had divided mini-serious games into different categories to stimulate a different part of the brain, including some that will induce physical activities. These mini-games aim to stimulate different cognitive brain functionalities such as memory, attention, problem-solving, response, and decision-making. Physical movements such as hand and upper body will be induced by the mini-games too. Secondly, the serious game was designed for easy manipulation by elderly users to perform simple and easy motions to induce sensory stimulation rather than selective response rate. Thirdly, the serious game was designed to use elderly-friendly background music to enhance the elderly's psychological familiarity. Next, the game has the flexibility to change the game stages according to the user's game level based on time spent playing the game. Finally, "TapBrain" utilized mini-mental state examination (MMSE) is used as an assessment model to measure potential dementia. Finally, the serious game will cover tutorials for users to know how to play the game. (Kiho K. et. al., 2016, p.416)

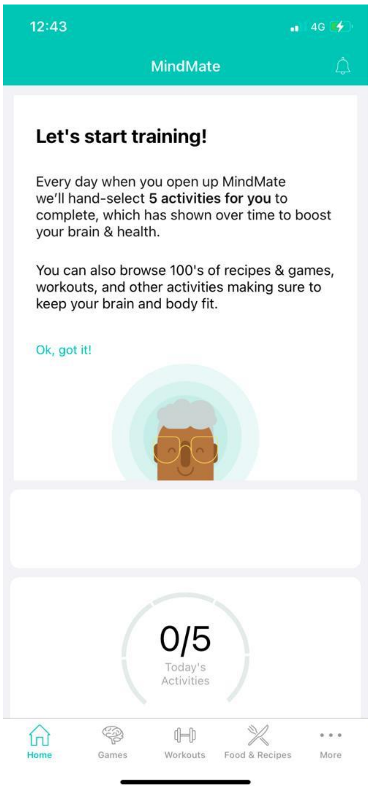
Weaknesses/Limitations

First, the proposed serious game for preventing dementia utilized a quick response (QR) code or near-field communication (NFC) to identity users. The proposed serious game had limited methods for users to login. It would be difficult for users if they are from other countries or lost their QR/NFC. Secondly, the users' game data are stored in a separate server and not on the user's device. The user will not be able to play the game while they are not connected to the internet as there will be no way to retrieve the data from the server. The author should consider this problem as the primary audience of this serious game will be the elderly. Many older adults are not familiar with internet technology and would not know how to go online by themselves. It would cause them unable to play the serious game.

2.2 System Review

2.2.1 MindMate

MindMate is a mobile Alzheimer's serious game application available on Apple IOS and Desktop/PC. MindMate is developed by the company MindMate LTD, and MindMate had been operating for more than 2 years. The application aims to help users transform and maintain wellness and health through everyday workouts and mental exercises which stimulate the mind. In MindMate, there are 3 major features such as games, workouts, and recipes. [17]



Let's start training!

Every day when you open up MindMate we'll hand-select **5 activities for you** to complete, which has shown over time to boost your brain & health.

You can also browse 100's of recipes & games, workouts, and other activities making sure to keep your brain and body fit.

Ok, got it!

0/5
Today's Activities

Figure 2.2: MindMate UI

Strengths

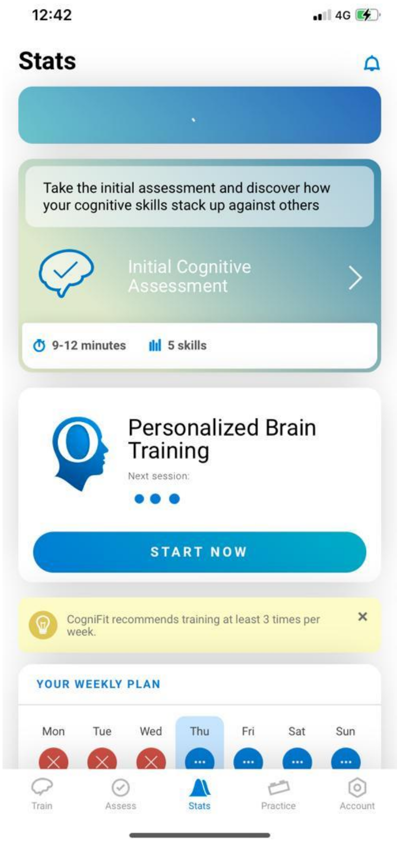
The first strength of MindMate is that the application collects information from its users such as gender, age, current condition, frequency of exercise, diet, and a small memory test before registering. With the information acquired, the system includes and customized suitable activities and games for the users. The application also records information about the sleep quality of the user. This feature shows users an overview of their sleep patterns. The application also includes fun and interactive games that stimulate the core cognitive abilities and enhance critical thinking. The games in the application aim to challenge four cognitive areas of the brain: problem-solving, speed, attention, and memory. Besides that, the application also includes exercise programs to ensure that users can stay physically fit. The applications will provide users with daily workout routines, nutrition advice, and healthy recipes to stay healthy by following the advice.

Weaknesses/Limitations

The first weakness of MindMate serious game application is that the MindMate interface is not elderly-friendly. The buttons and fonts in the application are too small for the elderly. Next, there is no tutorial for the serious game that educates the users on playing the games. It would cause the users to become confused while playing the game, without knowing how to play and complete the game. Lastly, the application does not allow different users to connect online. One of the risk factors of dementia is social. If users could connect through the application, it would be an enjoyable game for the users and reduce the risk of dementia. For example, users would not keep playing the same game by themselves and breaking their record as it would not be as challenging, and users will not get motivated to continue playing the game.

2.2.2 CogniFit

CogniFit is a provider of digital brain training games and tests. CogniFit is developed by Neuroscience experts and is available on multiple platforms such as windows, android, and IOS. CogniFit offers games such as memory games, puzzles, ingenious games, and many others that evaluate and train, and stimulate users' cognitive abilities. The games aimed to train the essential cognitive abilities such as memory, executive functions and reasoning, attention, concentration, coordination, and planning. [18]



Take the initial assessment and discover how your cognitive skills stack up against others

CogniFit recommends training at least 3 times per week.

Figure 2.3: CogniFit UI

Strengths

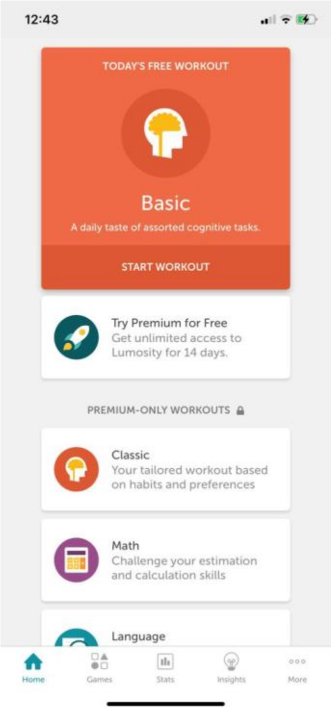
Firstly, the strength of CogniFit is that different games are designed and grouped as specific brain training programs to train an individual's cognitive skills such as concentration, coordination, driving, memory, and many more. Secondly, CogniFit provides detailed information about which cognitive skills will be tested according to the game chosen. For example, the application shows that the game "Word Quest" trained user's naming, visual perception, visual scanning, and width of field view cognitive abilities. Next, CogniFit also provides users with their cognitive scores after completing an entire training session or assessment. The results are provided in the form of a graph for easy interpretation. Users can download their personal data reports such as cognitive scores through the application. Furthermore, CogniFit provides personalized cognitive assessment games to the users according to their game performances in the application. Moreover, CogniFit games react to users' signs of progress by changing the game level, improving and testing users' cognitive skills. Finally, an interactive tutorial is provided by CogniFit to the users, and the tutorials are easy to understand as they are presented as overlay instructions.

Weaknesses/Limitations

The weakness of CogniFit is that the app does not provide specific cognitive skills score results after the user had completed one of the games. Instead, users need to complete an entire training session to get an overview of their cognitive scores, which may take users a long time. Next, the games in CogniFit do not have a leaderboard for users to compare performance results. Users will eventually get bored of playing the same game repeatedly as there are no challenges to keep the user motivated to play the game. The final weakness for CogniFit is that the activities that are provided are all focusing on cognitive training and stimulation. CogniFit should include some physical stimulation, such as hand and upper body movement, using the gyro sensor. Physical stimulation can be an essential attribute in determining cognitive abilities as physical movements are related to executive dysfunction, apraxia, and visuospatial and perceptual disabilities.

2.2.3 Lumosity

Lumosity is a brain training game application that provides games designed to create a fun and interactive way to train the user's brain. Lumosity is available for free on IOS and Andriod platforms. Lumosity game application offers sets of scientific games designed to improve users' working memory and stimulate their brains. The games available in Lumosity aims to provide cognitive training that challenges the core cognitive skills. [19]



A daily taste of assorted cognitive tasks.

Try Premium for Free
Get unlimited access to Lumosity for 14 days.

Classic
Your tailored workout based on habits and preferences

Math
Challenge your estimation and calculation skills

Language

Figure 2.4: Lumosity UI

Strengths

Firstly, the strength of Lumosity is that the game application will tailor the user brain training programs based on the user cognitive scores after the user had played some baseline cognitive training game. The baseline games include "Colour match," "Train of Thought," and Memory Matrix. Secondly, each game's step-by-step tutorials are interactive, which will let the user more understand what they need to do to complete the game. Next, an overview of the cognitive scores is presented in the cognitive Lumosity Performance Index (LPI), a standardized scale calculated from the user's game performance. The cognitive abilities taken into account of LPI are speed, memory, attention, flexibility, and problem-solving. Moreover, Lumosity also categorized games into different sets according to the cognitive abilities trained, such as memory, attention, problem-solving, flexibility, speed, language, and math. The categorized games will help users choose specific game types to play associated with the cognitive abilities the users are interested in. Furthermore, the user's cognitive score is being compared with other users worldwide. It will motivate the users to keep playing the game as users will be challenged to get into a higher cognitive percentile. Finally, the game in Lumosity will keep changing the game level based on the user's game performance. The game level will decrease when the user performs poorly in the current level, or the level will go up when the user is doing well with the game.

Weaknesses/Limitations

The weakness of Lumosity is that Lumosity does not provide detailed information about which cognitive abilities will be trained by playing the game. Next, Luminosity's games Sare all brain and cognitive abilities stimulation games, and there are no physical stimulation games. The physical movement stimulation games should also be included in Lumosity using gyro sensors to assess the cognitive abilities related to the brain and would not get bored quickly.

2.3 Proposed Serious Game

The proposed serious game in this project will cover all the strengths and weaknesses of all the systems reviewed. First, there will be a tailored set of games specially for the user according to their baseline game's cognitive scores. The serious games available will be 20tilize20d20d into set of games associated with the cognitive abilities trained. In addition, detailed information about the cognitive abilities trained by the serious game will be provided to the user. Each serious game will provide an interactive overlay tutorial to let the user quickly understand how to play the game. The serious games will change the level of difficulty based on the user performance. After the user complete the game, an overview of all cognitive scores will be displayed to inform the users about their cognitive health. The serious games will have a community leaderboard to let the users feel challenged and keep playing the game to achieve a higher score. Finally, there will be a cloud analytic to analyse user's game and cognitive performance in the serious game.

MindMate, CogniFit, Lumosity and proposed serious game Comparison

Feature/Application	MindMate	CogniFit	Lumosity	Proposed Serious game
Tailored/Specialized set of games	✓	✓	✓	✓
Categorised set of games	✓	✓	✓	✓
Detailed cognitive abilities information		✓		✓
Level changing based on game performance	✓	✓	✓	✓
Cognitive scores overview	✓	✓	✓	✓
Community Leaderboard			✓	✓
Interactive tutorials		✓	✓	✓
Cloud Analytic				✓

Table 2.1: MindMate, CogniFit, Lumosity and proposed serious game comparison

Chapter 3

System Methodology/Approach

3.1 Design Specification

3.1.1 Methodologies and General Work Procedures

Agile

The project implemented Agile Methodology which is an incremental and iterative development approach. The project involves breaking up the system into several modules and phases with Agile approach. The Agile framework being referenced is Extreme programming (XP) as the project is a single person work.

The selection of Extreme programming (XP) as the Agile framework is because the project timeline is short. The approach can help in saving cost, and time, removing the existence unproductive task and increase the focus on coding. The project should be able to anticipate regular requirement changes according to the biweekly meeting feedback. The regular testing of Extreme programming is also an advantage as different working modules should be able to be produced weekly. With this, testing the modules at the end development stage would ensure that most of the defects in each outcome modules are found.

The serious game development will be divided into 6 phases:

1. Initial planning
2. Design
3. Develop
4. Testing
5. Deploy
6. Launch of final product

Within these 6 phases, 4 phases which are design, develop, testing, and deploy is being implemented incremental and iteratively. Each separated modules will undergo the iterative cycle. The expected time period for each cycle would be 1-2 weeks.

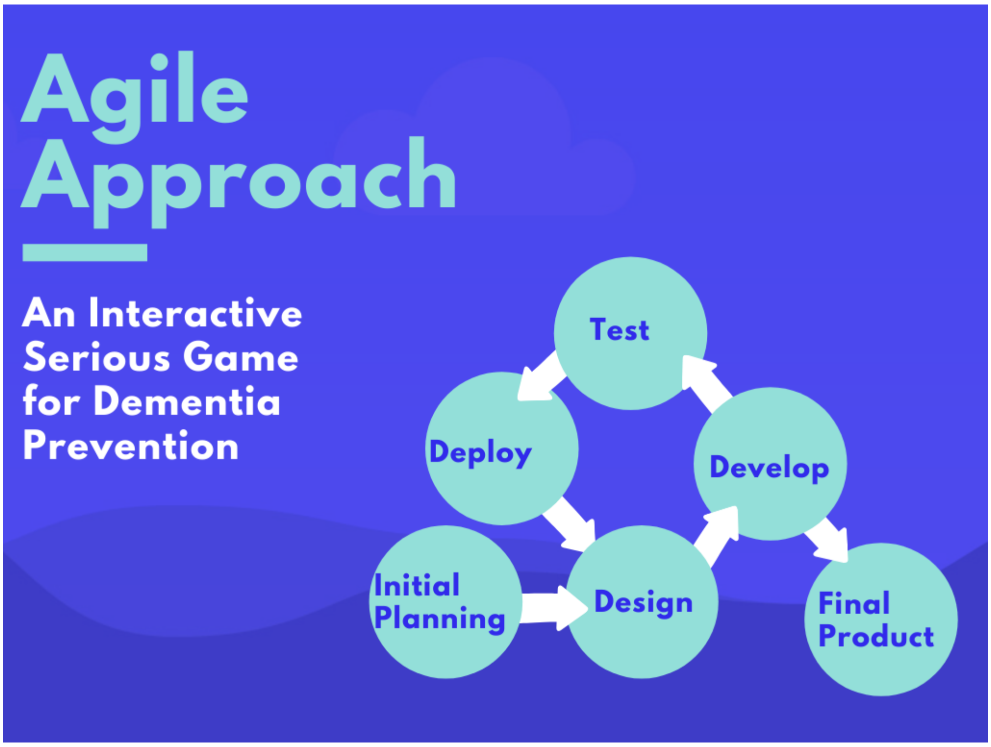


Figure 3.1: Agile Approach of An Interactive Serious Game for Dementia Prevention

Initial Planning Phase

First, an initial planning of the entire system is created. During the planning phase, the project's background and the problem at hand are studied. After conducting background study of the project, the problem statement is defined, and a review of various articles, academic journals, and systems is completed. The objectives, scope, and system functions are being 22tilize22d after defining the problems and potential solutions. During the planning phase, the timeline, use case diagram, games to include, modules required, and cloud platform are all planned.

Design

Following the planning phase, the project will transition into an iterative incremental development approach. Each iterative cycle represents a different module, such as login or games. Each iterative cycle will include phases such as design, development, testing, and deployment. An overall system architecture and flowchart are proposed during the design phase to provide an overview of how the entire system will look. A simple system architecture, user interface diagram, and component diagram are being created for each module. Furthermore, the current phase will include the design of game mechanisms such as player controls, score controls, and so on. Furthermore, test cases will be designed for each module in accordance with the requirements during this phase. Finally, the data that will be stored in the cloud is defined during the design phase.

Develop

Game characters and game object design are being created during the development phase. Unity3D is being used to arrange the game objects, and components that will be attached to the game objects. The C# scripts are written to allow the game object to be manipulated further during runtime. Following the completion of each module, an integration between Unity3D and PlayFab will be completed in order to upload related data to the cloud.

Testing

The development phase's deliverables are tested during the testing phase. The testing of development phase outcomes after each cycle ensures that early testing is achieved. Early module testing can reduce the risk of system failure when integrating all modules together. The black box testing will be used in the testing.

Final Product

Following the completion of the final module cycle, all modules that will be included in the system will be integrated to produce the final system. The final system will be tested to ensure that all requirements are met.

3.1.2 Development Approach

The serious game and the general user interface used different implementation methodologies. A top-down approach is used in developing the serious game and the bottom-up approach is used to develop the general user interface.

Serious Game

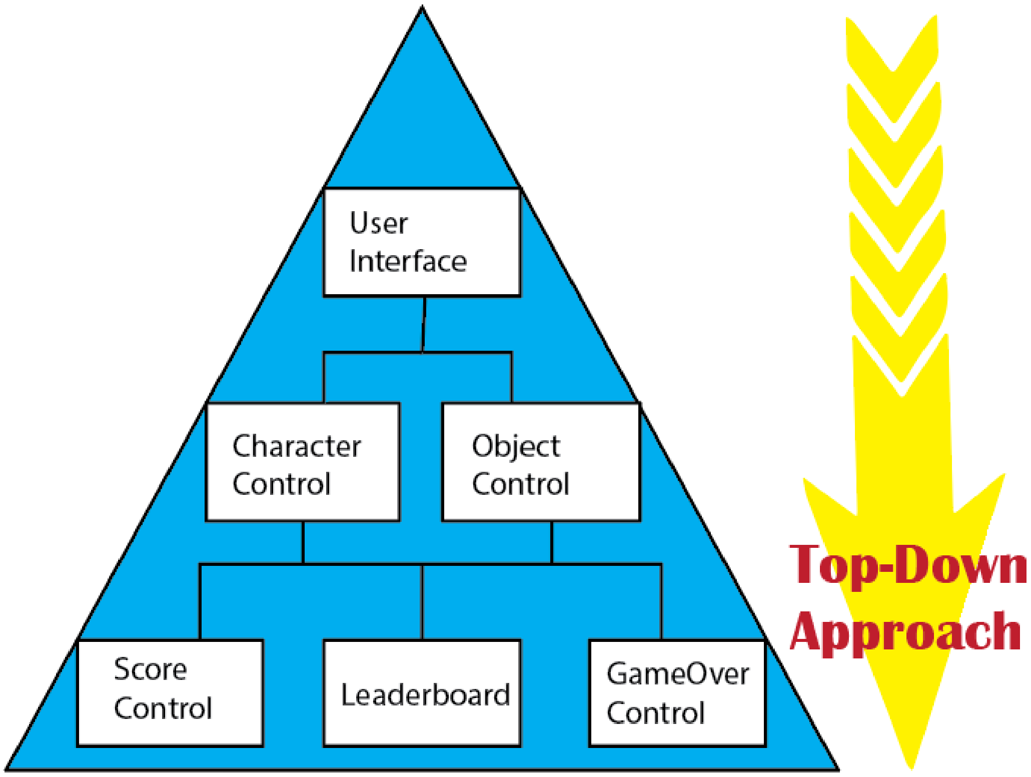


Figure 3.2: Serious game development methodologies

In developing each of the serious games, a top-down approach is used from developing user interface and to different game controls. The approach will be separated into three different level where the upper level is done first before the lower level.

In the first level, sprites and other useful user interface objects are being included into the scene. The game objects will be arranged based on their respective hierarchy such as the character object must be in the front of the scene. After arranging game object's hierarchy, some simple modification can be done to the game objects such as beautify the game. Next, the development will be moved to level two to implement character and objects controls. In the level two, the controllable variable such as character movement, object spawning, collisions, and physics are implemented using C# scripts. Multiple scripts will be used to change the character and object behaviours such as spawn time, or movements. After implementing the controls on the objects, a detailed testing is done on the serious game to find potential logic or programming errors based on the testing plan. The testing and fixing errors will be done repeatedly until the game can run smoothly and validated by all the test cases. A bug free serious game that is playable has been developed upon completion of level 2. Finally, some details such as game over, pause, scores, and leaderboard controls will be implemented in level 3. These details will provide users with a more complete controls over the serious game. The serious game will be included into the general flow of the game after completion of level 3.

General User Interface

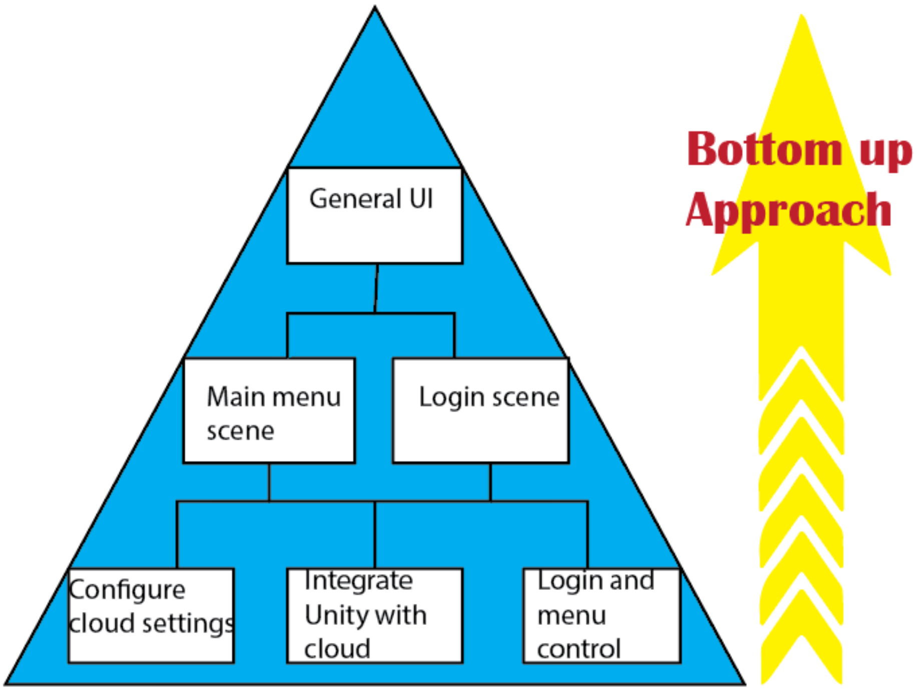


Figure 3.3: General User-Interface methodologies

The general user interface development will utilize the bottom-up approach. The general user interface includes login, main menu, game selection scenes. The approach will also be separated into 3 different stages. The lower level will be completed before continuing the top approach.

First, since the project data and information will be stored in the cloud, a deep analysis will be done on different cloud providers to differentiate them and find the suitable cloud provider. This project will use Microsoft Azure PlayFab as the cloud provider. After cloud selection, minimal configurations of the cloud settings will be needed according to the documentation. After configurations, the serious game project will be integrated with the PlayFab cloud through PlayFab API. Next, login, main menu and stage selection scripts will be implemented. The login scripts will include functions provided through PlayFab API so that registration and authentication can be done. In level 2, the main menu, game selection and login scene will be created. The script's methods that are created in level 3 will be used to associate with the buttons in main menu, game selection and login scene. After completing level 2, every scene will be linked together to create a general user interface flow in level 1.

3.2 System Design Diagram

3.2.1 System Flowchart

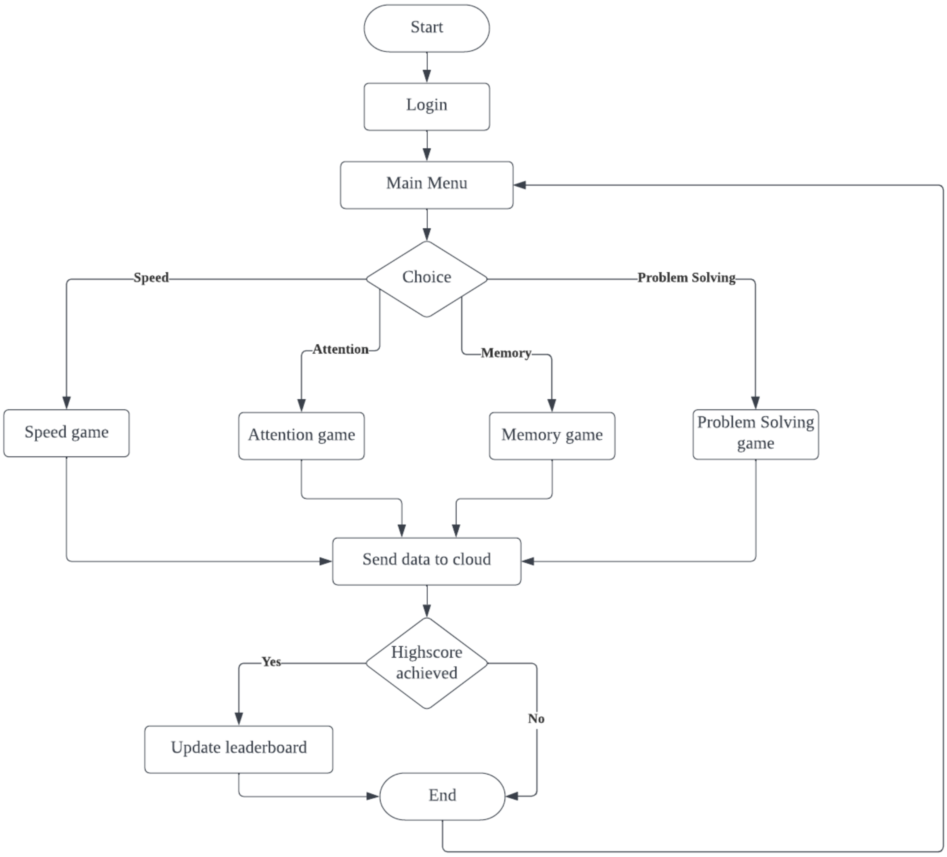


Figure 3.4: Flowchart for serious game

3.2.2 System Architecture Diagram

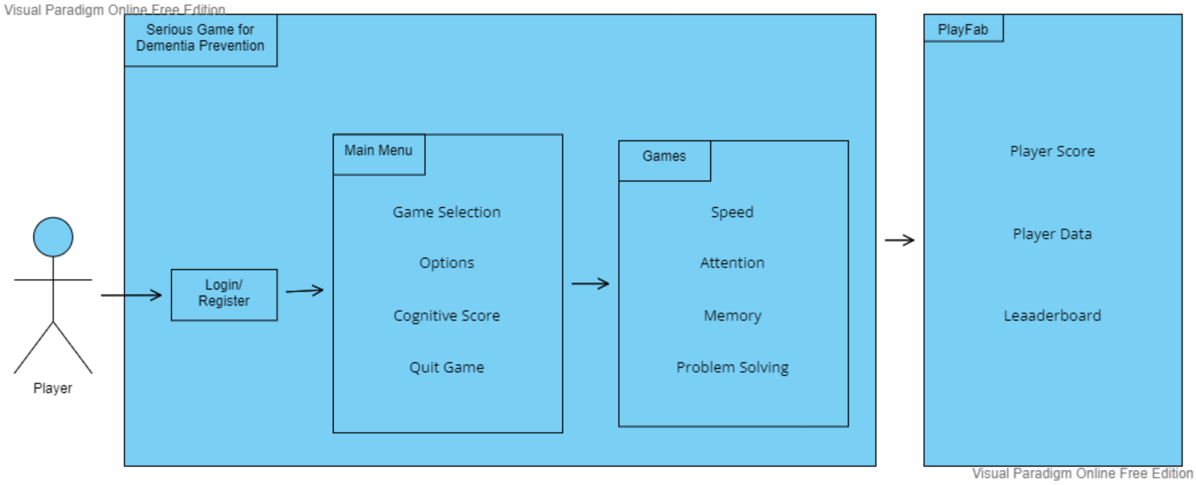


Figure 3.5: System Architecture Diagram for serious game

3.2.3 Use Case Diagram and Description

3.2.3.1 Use Case Diagram

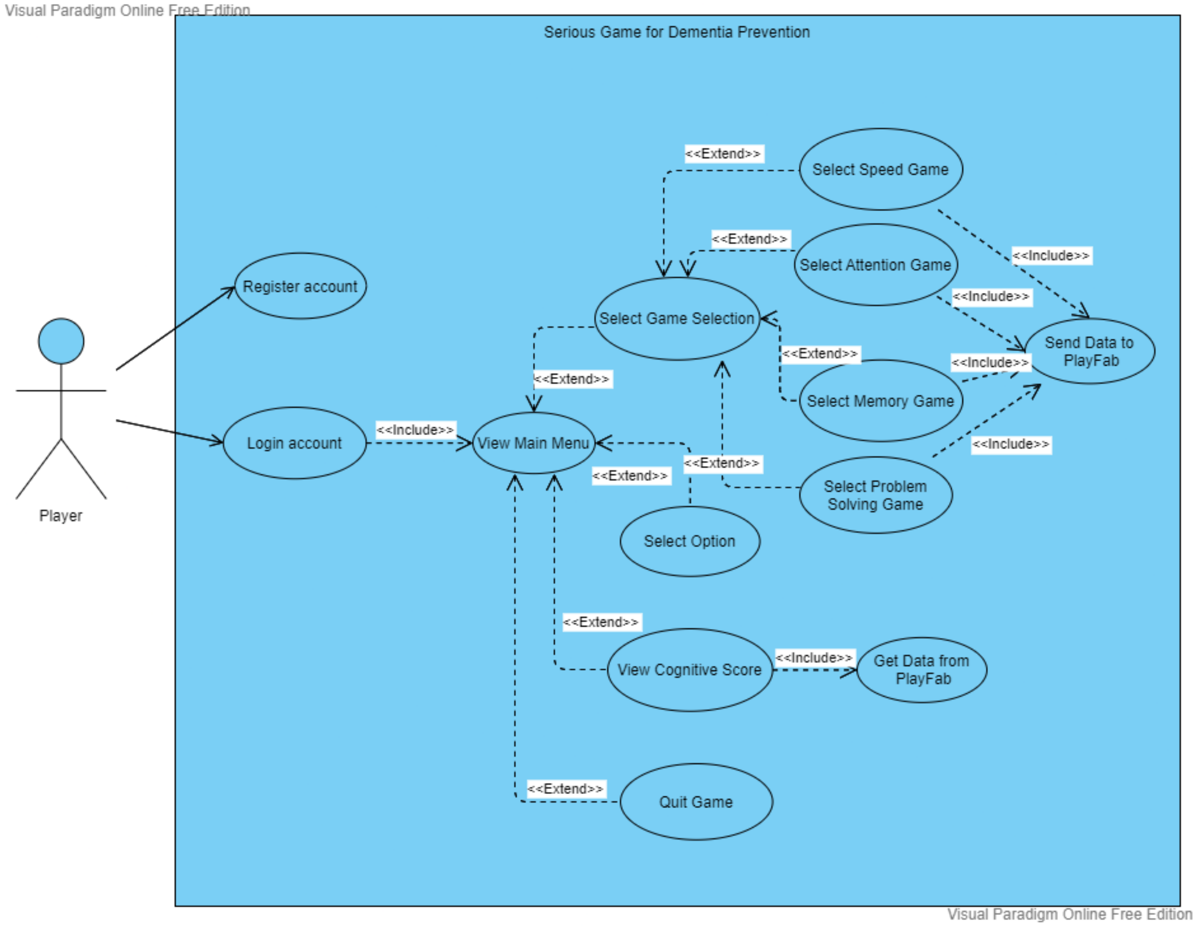


Figure 3.6: Use Case Diagram for serious game

3.2.3.2 Use Case Description

Use Case ID	UC00	**Version**	1.0
Use Case	Register Account		
Purpose	To allow Player to create new account.		
Actor	Player		
Trigger	Player clicks on the 'Register' button.		
Precondition	Player had installed and run the game and does not have an account.		
Scenario Name	**Step**	**Action**	
Main Flow	1	System request for email and password.	
	2	Player inputs email as registration credentials.	
	3	Player inputs password for authentication purpose.	
	4	Player clicks the 'Register Button'.	
	5	System sends the information to the cloud.	
	6	Player account registration completed.	

Table 3.1: Use Case Description for register account

Use Case ID	UC01	**Version**	1.0
Use Case	Login Account		
Purpose	To allow Player to login to their account.		
Actor	Player		
Trigger	Player clicks on the ‘Login’ button.		
Precondition	Player already has an account.		
Scenario Name	**Step**	**Action**	
Main Flow	1	System request for email and password.	
	2	Player inputs email as registration credentials.	
	3	Player inputs password for authentication purpose.	
	4	Player clicks the ‘Login’ button.	
	5	System sends the information to the cloud.	
	6	System validates the player’s credentials.	
	7	Player account login successful.	
Alternate Flow – Invalid Email and Password	2.1	Player inputs invalid email and password.	
	2.2	System sends information to the cloud.	
	2.3	System validates the player’s credentials.	
	2.4	System prompts the error message “Invalid Email or Password. Please try again”.	
	2.5	Back to Main Flow step 1.	

Table 3.2: Use Case Description for login account

Use Case ID	UC02	**Version**	1.0
Use Case	View main menu		
Purpose	To allow player to choose action based on main menu.		
Actor	Player		
Trigger	Player successfully login to the system.		
Precondition	Player had successfully logged into the system and redirected to the Main Menu.		
Scenario Name	**Step**	**Action**	
Main Flow	1	System displays different options for player to choose.	
	2	Player selects action from main menu.	
Sub Flow-Game Selection	2a.1	Player selects ‘Game Selection’.	
	2a.2	System redirects player to ‘Game Selection’ scene.	
Sub Flow-Cognitive Score	2b.1	Player selects ‘Cognitive Score’.	
	2b.2	System redirects the player to ‘Cognitive Score’ scene.	
Sub Flow-Cognitive Score	2c.1	Player selects ‘Options’.	
	2c.2	System redirects the player to ‘Options’ scene.	
Sub Flow-Quit Game	2d.1	Player selects ‘Quit Game’.	
	2d.2	System redirects the player to call quit game.	

Table 3.3: Use Case Description for main menu

Use Case ID	UC03	**Version**	1.0
Use Case	Select game selection		
Purpose	To allow player to choose games from four categories.		
Actor	Player		
Trigger	Player chose ‘Game Selection’ from the main menu.		
Precondition	Player is logged in and selected ‘Game Selection’ from the main menu		
Scenario Name	**Step**	**Action**	
Main Flow	1	System displays different games for player to choose.	
	2	Player selects game from Game Selection menu.	
Sub Flow-Speed	2a.1	Player selects ‘Speed Game’.	
	2a.2	System redirects player to ‘Speed Game’ scene.	
Sub Flow-Attention	2b.1	Player selects ‘Attention Game’.	
	2b.2	System redirects player to ‘Attention Game’ scene.	
Sub Flow-Memory	2c.1	Player selects ‘Memory Game’.	
	2c.2	System redirects player to ‘Memory Game’ scene.	
Sub Flow-Problem Solving	2d.1	Player selects ‘Problem Solving Game’.	
	2d.2	System redirects player to ‘Problem Solving Game’ scene.	

Table 3.4: Use Case Description for game selection

Use Case ID	UC04	**Version**	1.0
Use Case	Speed Game		
Purpose	To allow player to play game in speed categories.		
Actor	Player		
Trigger	Player chose ‘Speed Game’ from the Game selection.		
Precondition	-		
Scenario Name	**Step**	**Action**	
Main Flow	1	System run ‘Speed’ game scene.	
	2	Player controls and plays the game.	
	3	Player completes the game.	
	4	System display game over options for the users.	
Alternate Flow – Pause Game	3.1	Player pauses the game.	
	3.2	System display pause options to the player.	
Sub Flow – Resume Game	3.2a.1	Player chooses to resume the game.	
	3.2a.2	System resumes the game.	
	3.2a.3	Back to main flow step 2.	
Sub Flow – Restart Game	3.2b.1	Player chooses to replay the game.	
	3.2b.2	System restarts the game.	
Sub Flow – Main Menu	3.2c.1	Player chooses to go to main menu.	
	3.2c.2	System redirects player to ‘Main Menu’ scene.	
Sub Flow – Quit Game	3.2d.1	Player chooses to go to quit game.	
	3.2d.2	System redirects the player to call quit game.	

Table 3.5 Use Case Description for speed game

Use Case ID	UC05	**Version**	1.0
Use Case	Attention Game		
Purpose	To allow player to play game in attention categories.		
Actor	Player		
Trigger	Player chose 'Attention Game' from the Game selection.		
Precondition	-		
Scenario Name	**Step**	**Action**	
Main Flow	1	System run 'Attention' game scene.	
	2	Player controls and plays the game.	
	3	Player completes the game.	
	4	System display game over options for the users.	
Alternate Flow – Pause Game	3.1	Player pauses the game.	
	3.2	System display pause options to the player.	
Sub Flow – Resume Game	3.2a.1	Player chooses to resume the game.	
	3.2a.2	System resumes the game.	
	3.2a.3	Back to main flow step 2.	
Sub Flow – Restart Game	3.2b.1	Player chooses to restart the game.	
	3.2b.2	System restarts the game.	
Sub Flow – Main Menu	3.2c.1	Player chooses to go to main menu.	
	3.2c.2	System redirects player to 'Main Menu' scene.	
Sub Flow – Quit Game	3.2d.1	Player chooses to go to quit game.	
	3.2d.2	System redirects the player to call quit game.	

Table 3.6: Use Case Description for attention game

Use Case ID	UC06	**Version**	1.0
Use Case	Memory Game		
Purpose	To allow player to play game in memory categories.		
Actor	Player		
Trigger	Player chose ‘Memory Game’ from the Game selection.		
Precondition	-		
Scenario Name	**Step**	**Action**	
Main Flow	1	System run ‘Memory’ game scene.	
	2	Player controls and plays the game.	
	3	Player completes the game.	
	4	System display game over options for the users.	
Alternate Flow – Pause Game	3.1	Player pauses the game.	
	3.2	System display pause options to the player.	
Sub Flow – Resume Game	3.2a.1	Player chooses to resume the game.	
	3.2a.2	System resumes the game.	
	3.2a.3	Back to main flow step 2.	
Sub Flow – Restart Game	3.2b.1	Player chooses to restart the game.	
	3.2b.2	System resumes the game.	
Sub Flow – Main Menu	3.2c.1	Player chooses to go to main menu.	
	3.2c.2	System redirects player to ‘Main Menu’ scene.	
Sub Flow – Quit Game	3.2d.1	Player chooses to go to quit game.	
	3.2d.2	System redirects the player to call quit game.	

Table 3.7: Use Case Description for memory game

Use Case ID	UC07	**Version**	1.0
Use Case	Problem Solving Game		
Purpose	To allow player to play game in problem solving categories.		
Actor	Player		
Trigger	Player chose 'Problem Solving Game' from the Game selection.		
Precondition	-		
Scenario Name	**Step**	**Action**	
Main Flow	1	System run 'Problem solving' game scene.	
	2	Player controls and plays the game.	
	3	Player completes the game.	
	4	System display game over options for the users.	
Alternate Flow – Pause Game	3.1	Player pauses the game.	
	3.2	System display pause options to the player.	
Sub Flow – Resume Game	3.2a.1	Player chooses to resume the game.	
	3.2a.2	System resumes the game.	
	3.2a.3	Back to main flow step 2.	
Sub Flow – Restart Game	3.2b.1	Player chooses to restart the game.	
	3.2b.2	System restarts the game.	
Sub Flow – Main Menu	3.2c.1	Player chooses to go to main menu.	
	3.2c.2	System redirects player to 'Main Menu' scene.	
Sub Flow – Quit Game	3.2d.1	Player chooses to go to quit game.	
	3.2d.2	System redirects the player to call quit game.	

Table 3.8: Use Case Description for problem solving game

Use Case ID	UC08	**Version**	1.0
Use Case	Send data to PlayFab.		
Purpose	To store player data and score to the PlayFab.		
Actor	-		
Trigger	Player had registered account.		
Precondition	The player had completed a game and game over scene appear.		
Scenario Name	**Step**	**Action**	
Main Flow	1	Player finished playing a game.	
	2	System retrieved the player score.	
	3	System parses the player score into key-value pair.	
	4	System sends the data to PlayFab via API method.	

Table 3.9: Use Case Description for PlayFab send data

Use Case ID	UC09	**Version**	1.0
Use Case	Select Option.		
Purpose	To allow player to change their game setting.		
Actor	Player		
Trigger	Player chose ‘Options’ from the main menu.		
Precondition	-		
Scenario Name	**Step**	**Action**	
Main Flow	1	System redirects player to ‘option’ menu.	
	2	Player configures the settings.	
Sub Flow – Game Resolution	2a.1	Player changes the game resolution.	
	2a.2	System applies changes to the game resolution.	
Sub Flow – Game Volume	3.2b.1	Player changes the game volume.	
	3.2b.2	System increase/decrease game volume based on player setting.	
Sub Flow – Full Screen	3.2c.1	Player checks/unchecks full screen.	
	3.2c.2	System changes the game into full screen/windowed mode.	

Table 3.10: Use Case Description for select option

Use Case ID	UC10	**Version**	1.0
Use Case	View Cognitive Score.		
Purpose	To provide an overview of player’s cognitive performance.		
Actor	Player		
Trigger	Player chose ‘Cognitive Score’ from the main menu.		
Precondition	-		
Scenario Name	**Step**	**Action**	
Main Flow	1	System redirects player to ‘Cognitive Score’ scene.	
	2	System gets player data from PlayFab.	
	3	System calculates cognitive performance.	
	4	System displays player cognitive performance.	

Table 3.11: Use Case Description for view cognitive score

Use Case ID	UC11	**Version**	1.0
Use Case	Get data to PlayFab.		
Purpose	To get player data that is stored in the PlayFab.		
Actor	-		
Trigger	System asked for player data via API.		
Precondition	Player had game data stored in PlayFab.		
Scenario Name	**Step**	**Action**	
Main Flow	1	System sends player’s data to PlayFab via API calls.	
	2	PlayFab gets player data in key-value pair.	
	3	PlayFab sends back the player data to the system.	

Table 3.12: Use Case Description for PlayFab get data

Use Case ID	UC12	**Version**	1.0
Use Case	Quit Game.		
Purpose	To quit the game.		
Actor	Player		
Trigger	Player chose ‘Quit Game’ option in the main menu.		
Precondition	-.		
Scenario Name	**Step**	**Action**	
Main Flow	1	Player chose ‘Exit game’ in main menu.	
	2	System logout the player.	
	3	System exits.	

Table 3.13: Use Case Description for quit game

3.2.4 Activity Diagram

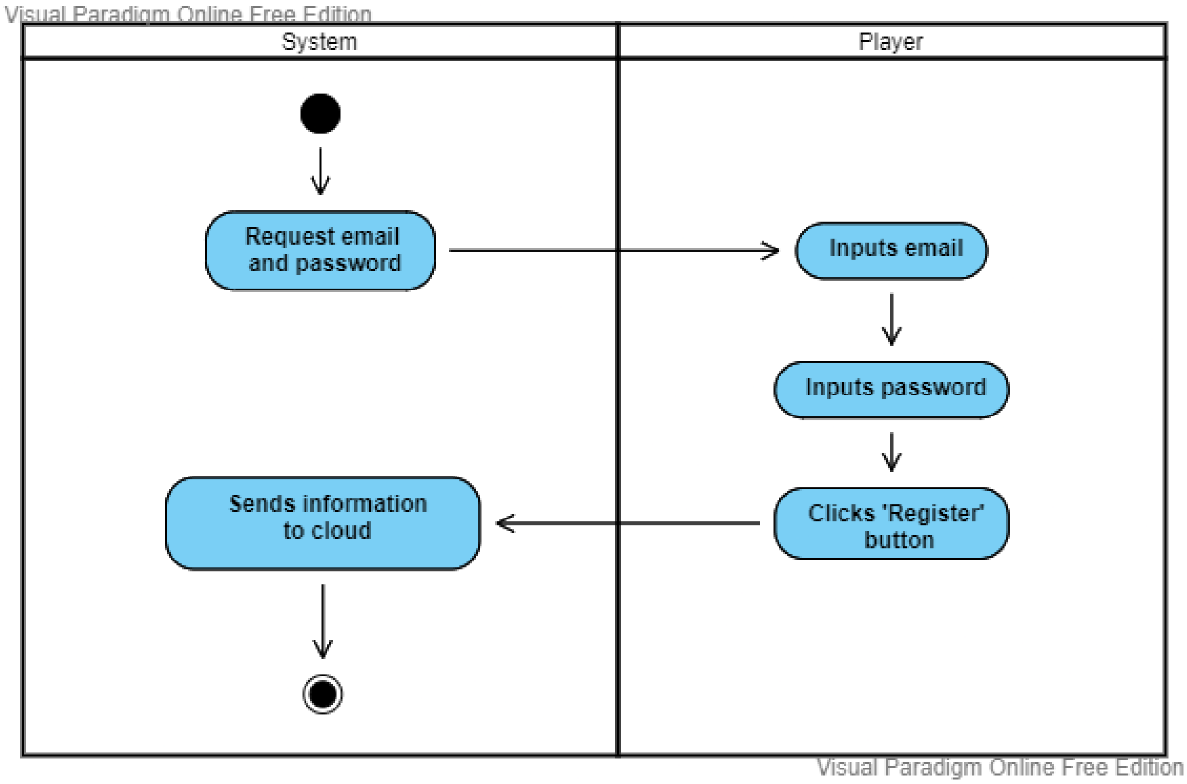

Visual Paradigm Online Free Edition
System
Player
Request email and password
Inputs email
Inputs password
Clicks 'Register' button
Sends information to cloud
Visual Paradigm Online Free Edition

Figure 3.7: Register account activity diagram

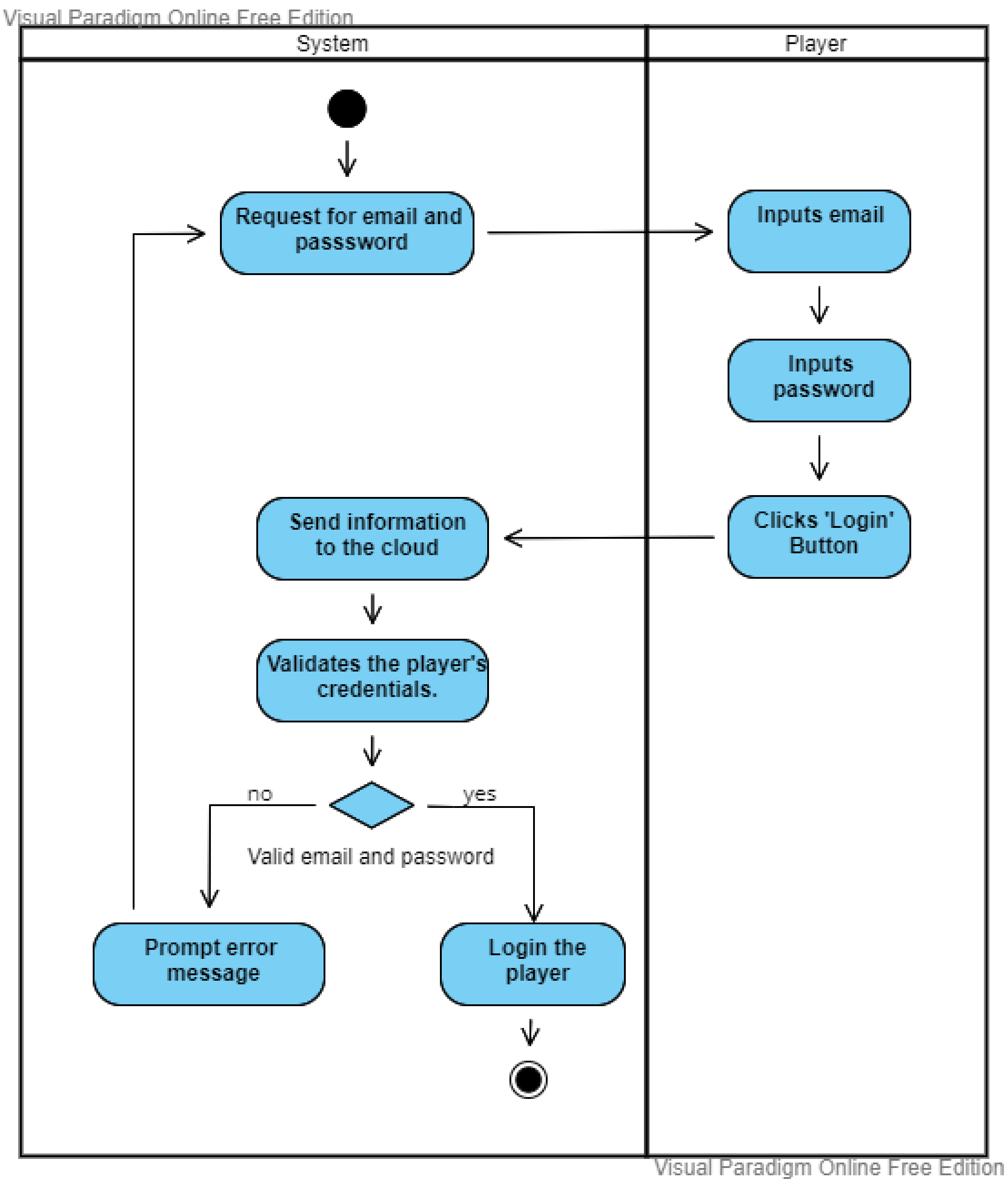

Visual Paradigm Online Free Edition
System
Player
Request for email and passsword
Inputs email
Inputs password
Clicks 'Login' Button
Send information to the cloud
Validates the player's credentials.
no
yes
Valid email and password
Prompt error message
Login the player
Visual Paradigm Online Free Edition

Figure 3.8: Login account activity diagram

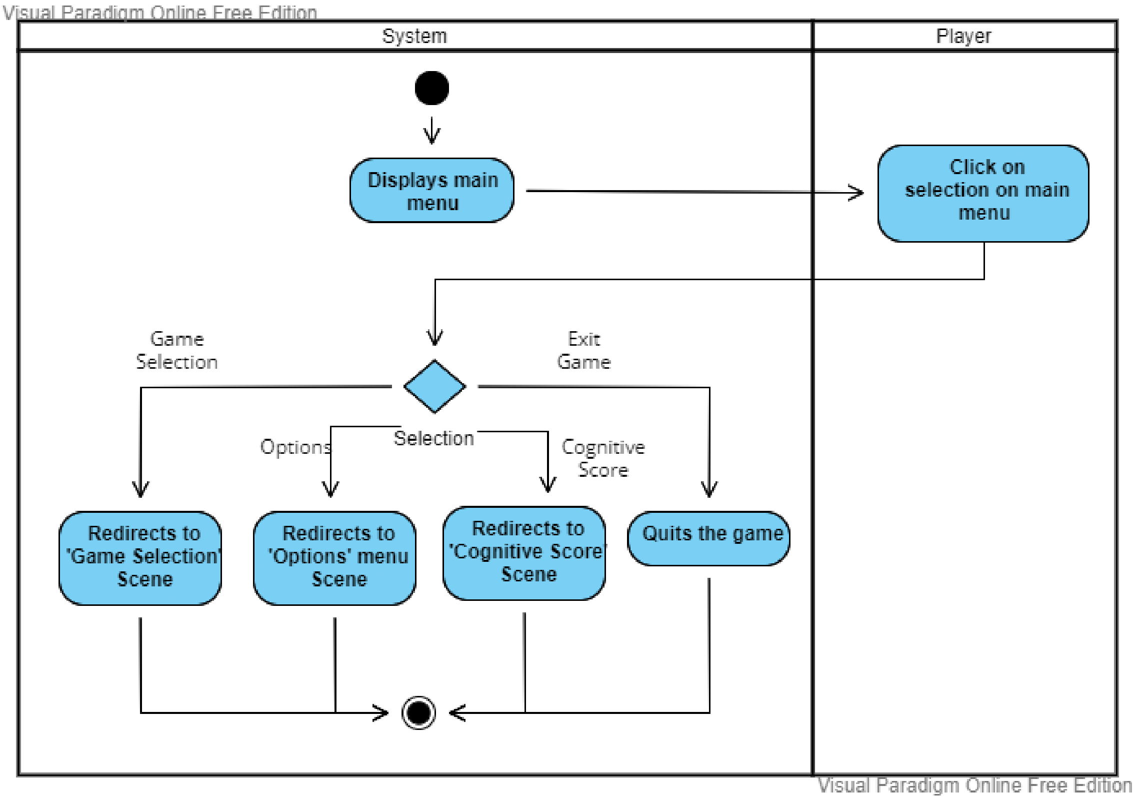

Visual Paradigm Online Free Edition
System
Player
Displays main menu
Click on selection on main menu
Game Selection
Exit Game
Options
Selection
Cognitive Score
Redirects to 'Game Selection' Scene
Redirects to 'Options' menu Scene
Redirects to 'Cognitive Score' Scene
Quits the game
Visual Paradigm Online Free Edition

Figure 3.9: Main menu activity diagram

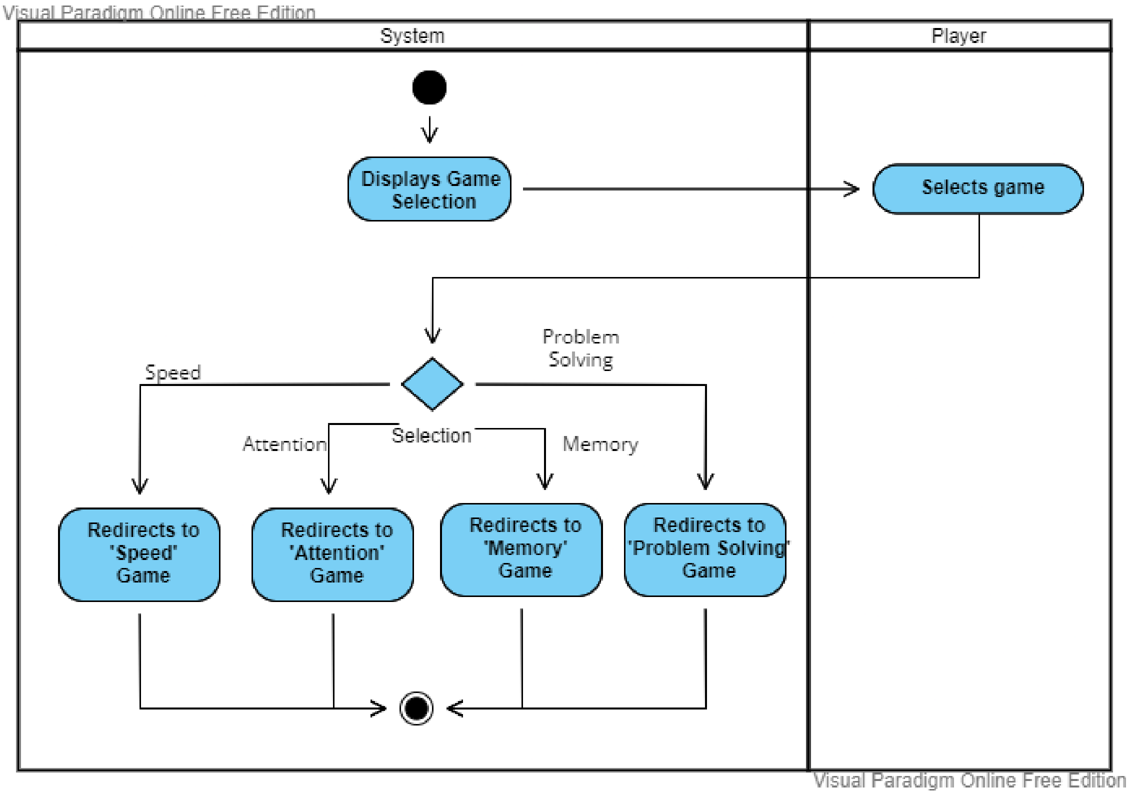

Visual Paradigm Online Free Edition
System
Player
Displays Game Selection
Selects game
Speed
Problem Solving
Attention
Selection
Memory
Redirects to 'Speed' Game
Redirects to 'Attention' Game
Redirects to 'Memory' Game
Redirects to 'Problem Solving' Game
Visual Paradigm Online Free Edition

Figure 3.10: Game selection activity diagram

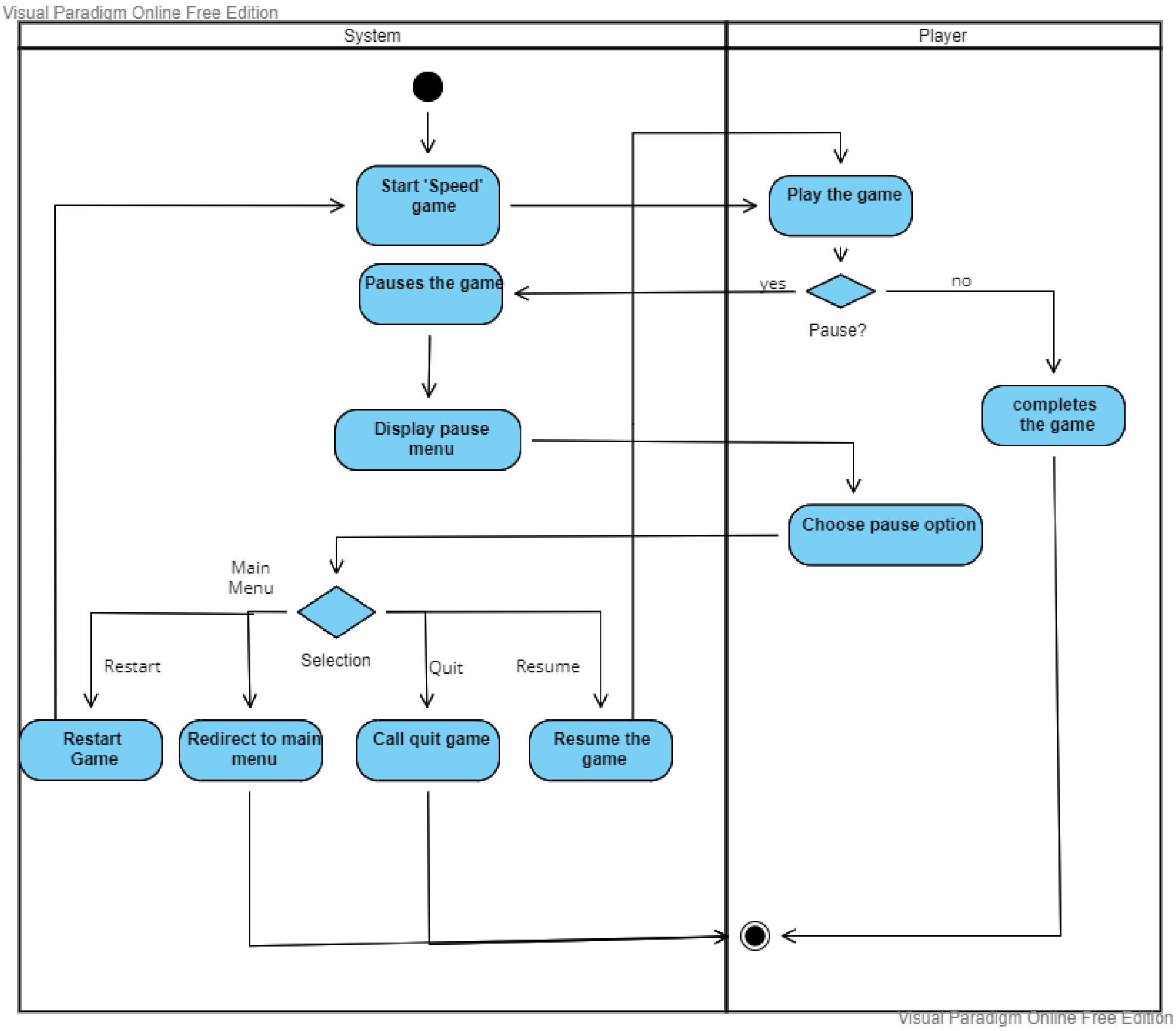


Figure 3.11: Speed game activity diagram

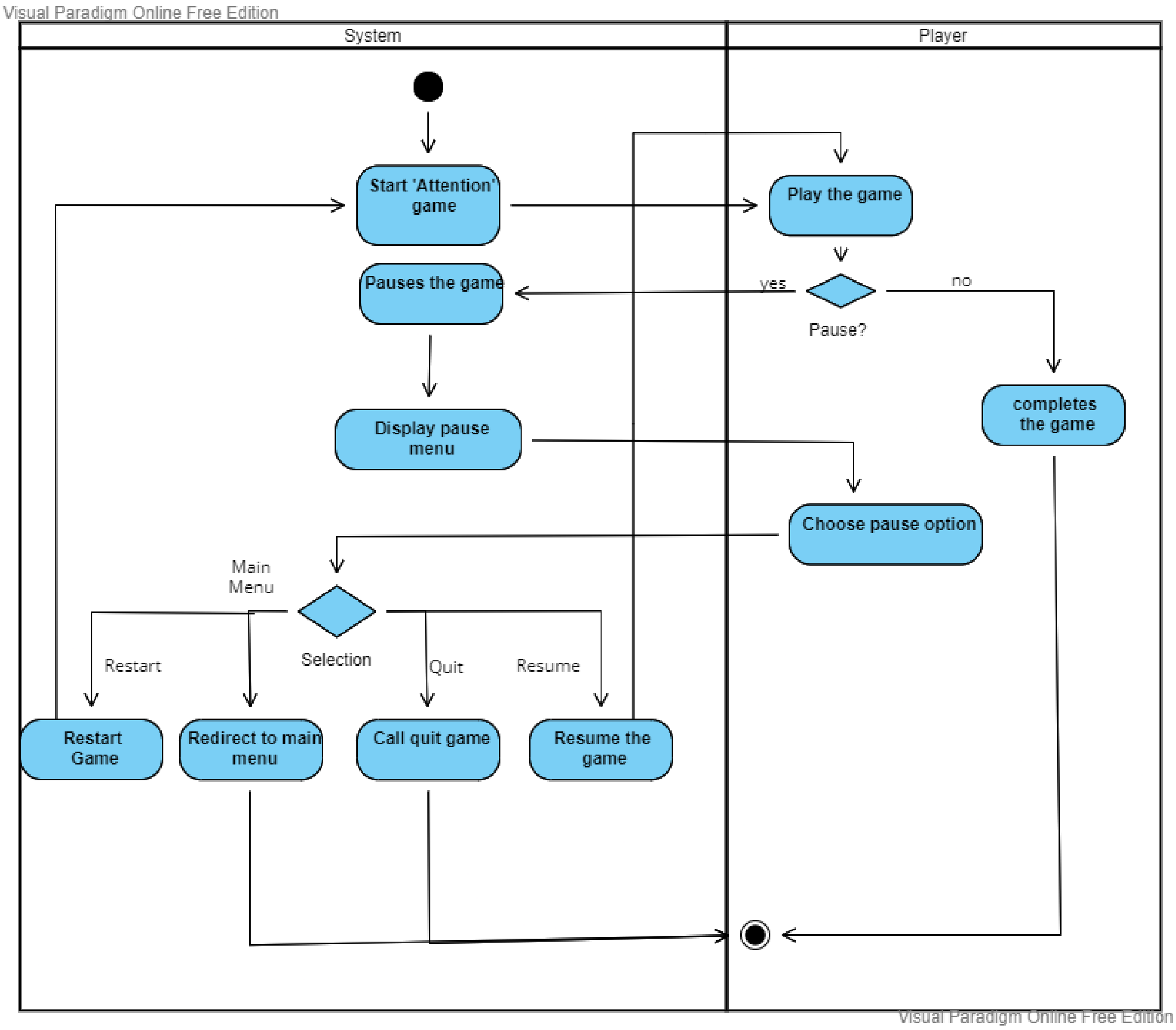


Figure 3.12: Attention game activity diagram

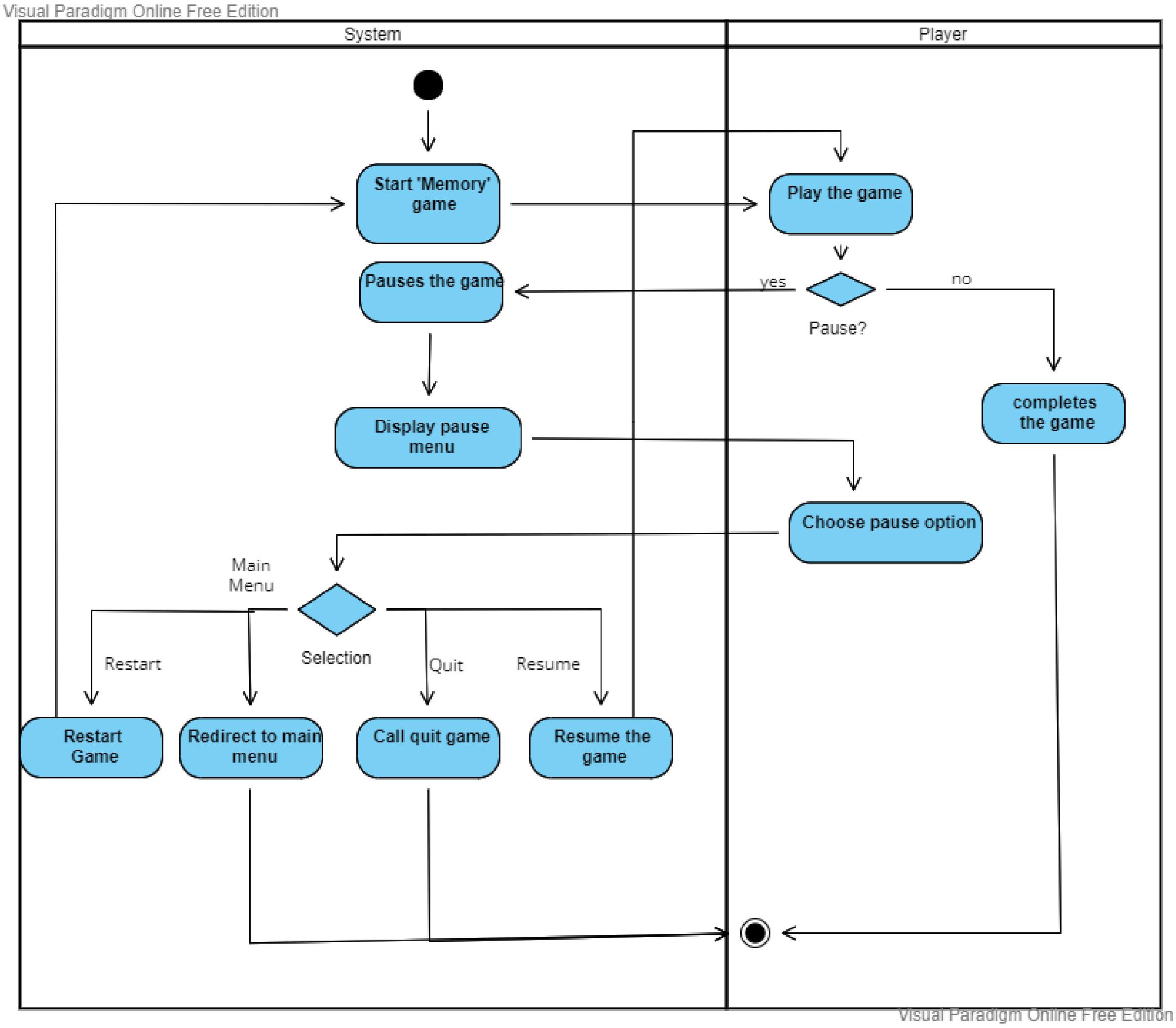


Figure 3.13: Memory game activity diagram

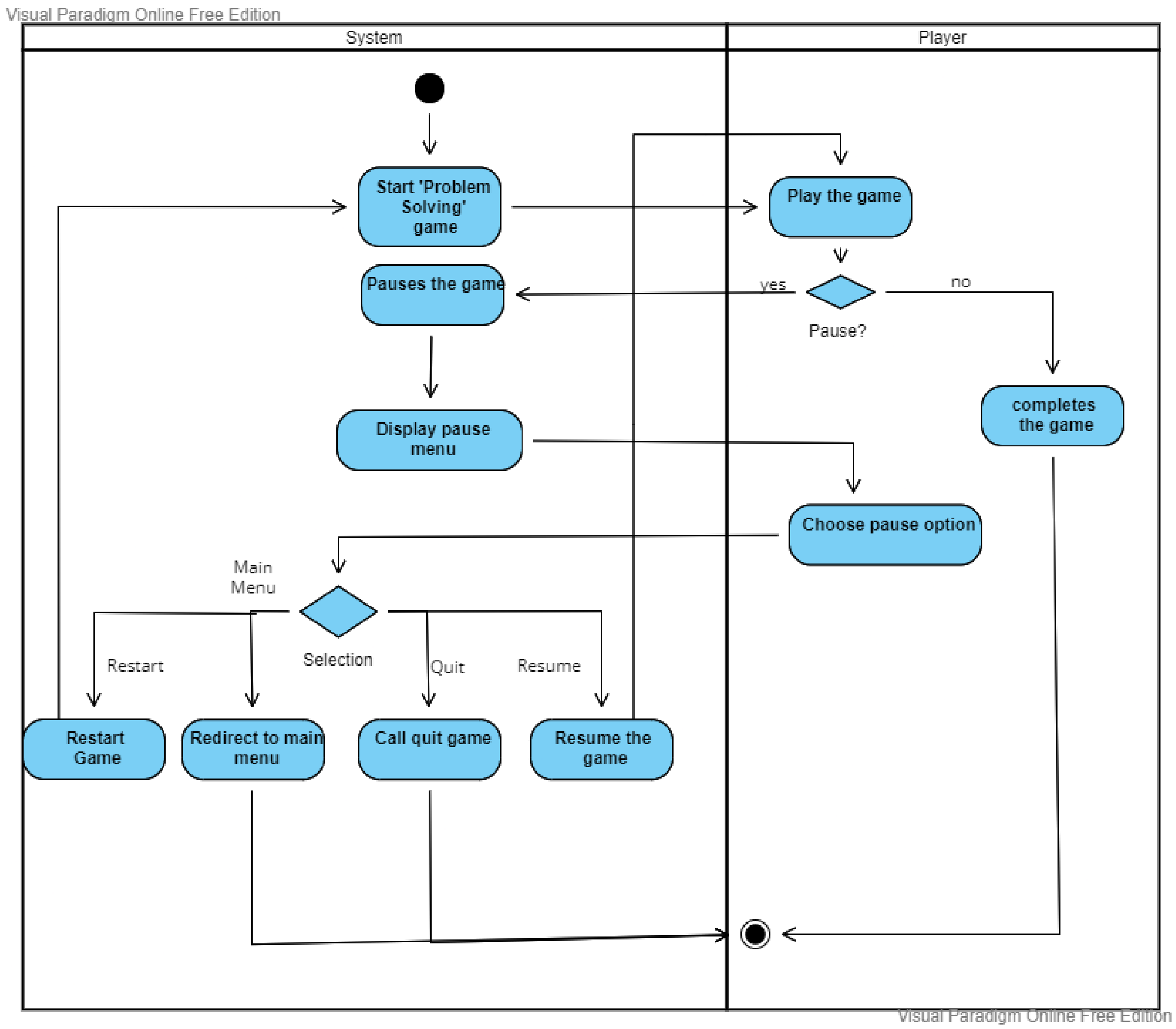


Figure 3.14: Problem solving game activity diagram

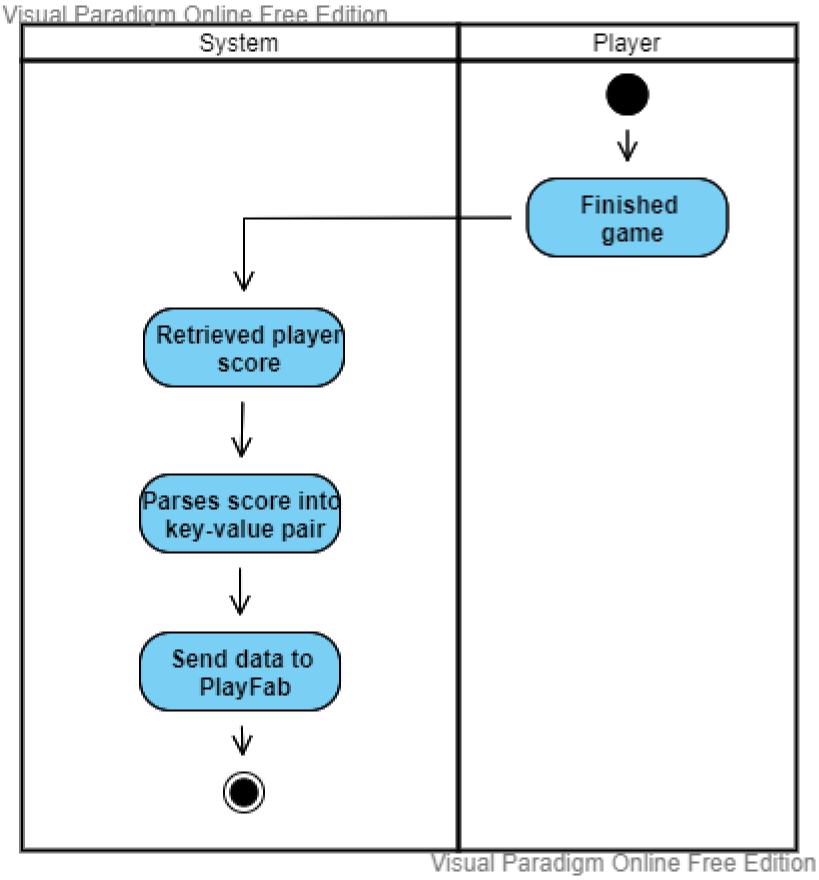

Visual Paradigm Online Free Edition
System
Player
Finished game
Retrieved player score
Parses score into key-value pair
Send data to PlayFab
Visual Paradigm Online Free Edition

Figure 3.15: PlayFab send data activity diagram

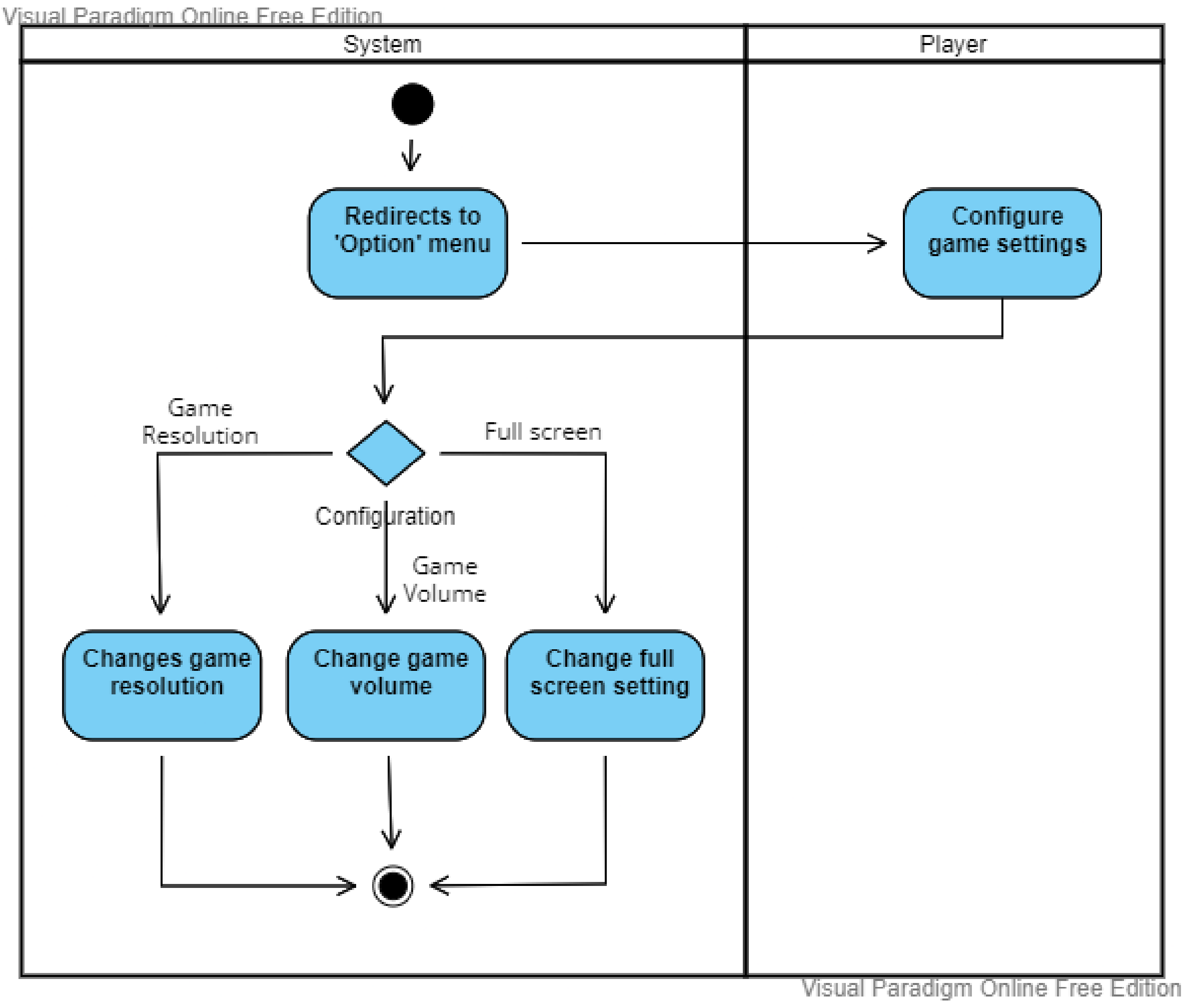


Figure 3.16: Select option activity diagram

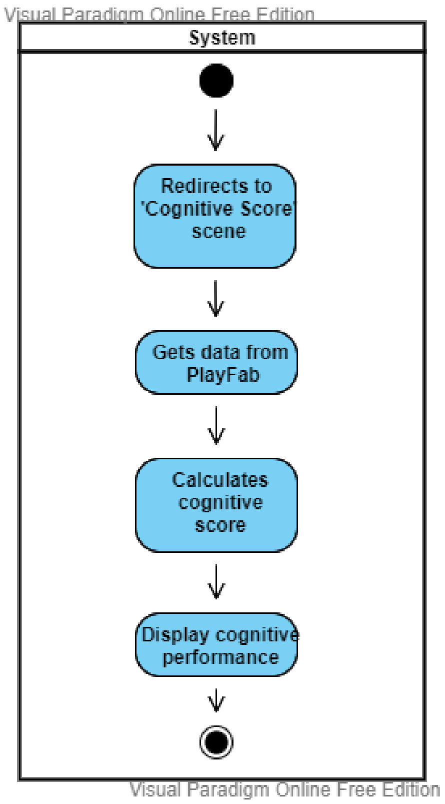

Visual Paradigm Online Free Edition
System
Redirects to 'Cognitive Score' scene
Gets data from PlayFab
Calculates cognitive score
Display cognitive performance
Visual Paradigm Online Free Edition

Figure 3.17: Cognitive score activity diagram

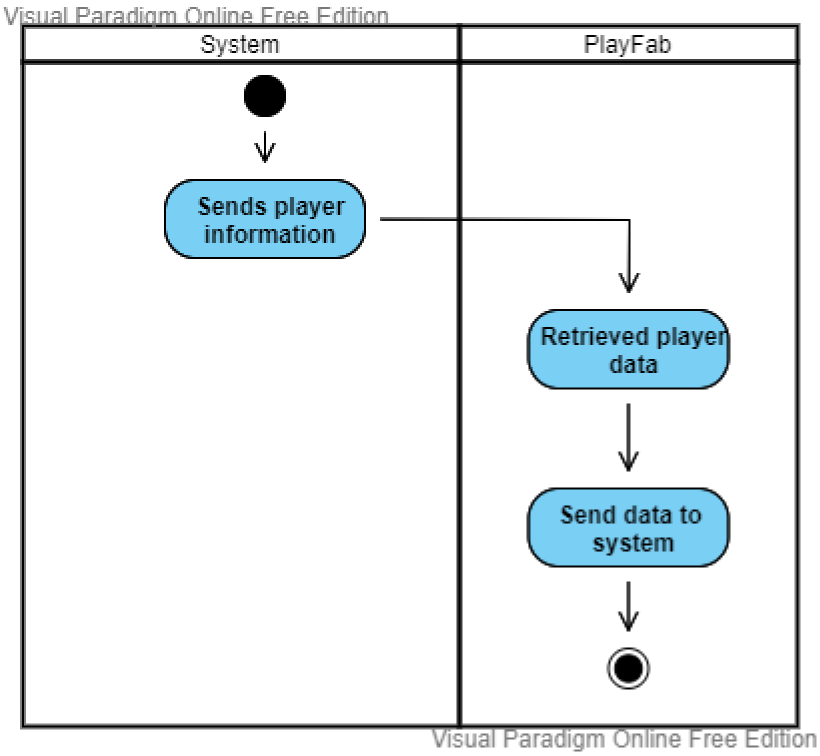


Figure 3.18: PlayFab get data activity diagram

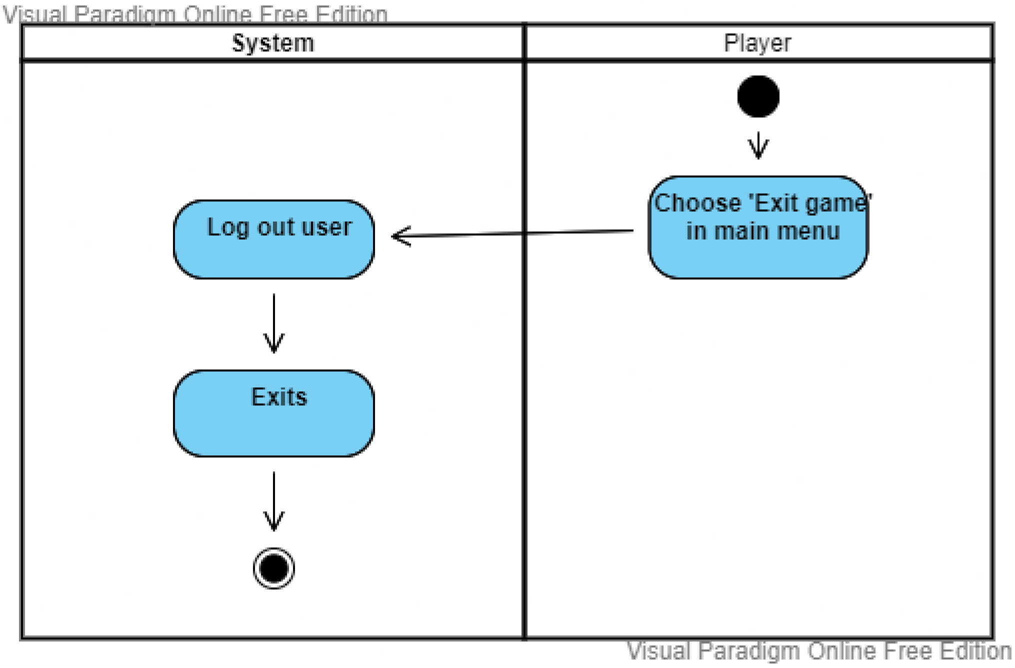

Visual Paradigm Online Free Edition
System
Player
Choose 'Exit game' in main menu
Log out user
Exits
Visual Paradigm Online Free Edition

Figure 3.19: Quit game activity diagram

Chapter 4

System Design

4.1 System Component Diagram

4.1.1 Subsystem Architecture

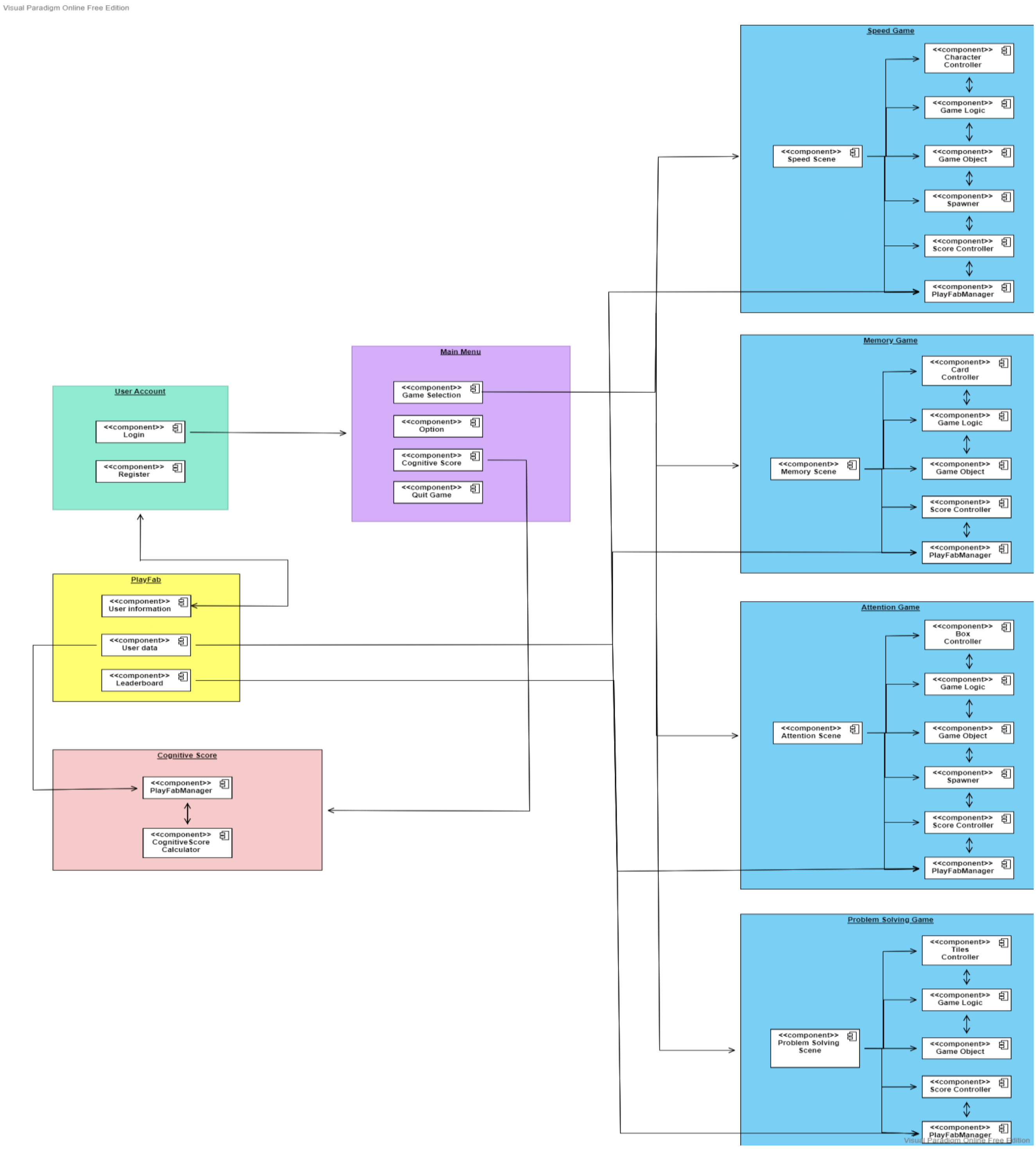

Visual Paradigm Online Free Edition
User Account
<<component>> Login
<<component>> Register
Main Menu
<<component>> Game Selection
<<component>> Option
<<component>> Cognitive Score
<<component>> Quit Game
PlayFab
<<component>> User information
<<component>> User data
<<component>> Leaderboard
Cognitive Score
<<component>> PlayFabManager
<<component>> Cognitive Score Calculator
Speed Game
<<component>> Speed Scene
<<component>> Character Controller
<<component>> Game Logic
<<component>> Game Object
<<component>> Spawner
<<component>> Score Controller
<<component>> PlayFabManager
Memory Game
<<component>> Memory Scene
<<component>> Card Controller
<<component>> Game Logic
<<component>> Game Object
<<component>> Score Controller
<<component>> PlayFabManager
Attention Game
<<component>> Attention Scene
<<component>> Box Controller
<<component>> Game Logic
<<component>> Game Object
<<component>> Spawner
<<component>> Score Controller
<<component>> PlayFabManager
Problem Solving Game
<<component>> Problem Solving Scene
<<component>> Tiles Controller
<<component>> Game Logic
<<component>> Game Object
<<component>> Score Controller
<<component>> PlayFabManager
Visual Paradigm Online Free Edition

Figure 4.1: System architecture

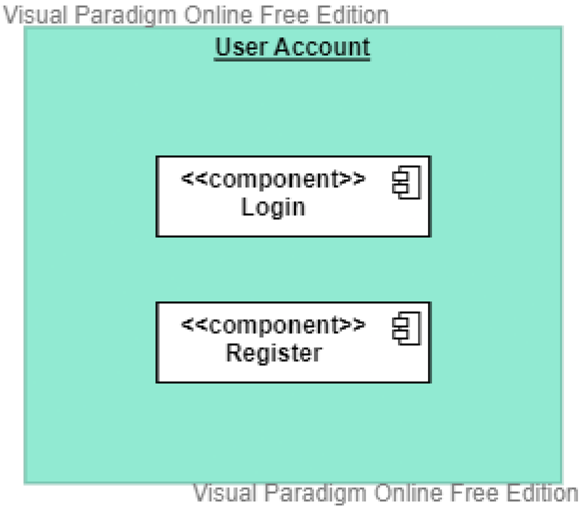

Visual Paradigm Online Free Edition
User Account
<<component>>
Login
<<component>>
Register
Visual Paradigm Online Free Edition

Figure 4.2: User account subsystem component diagram

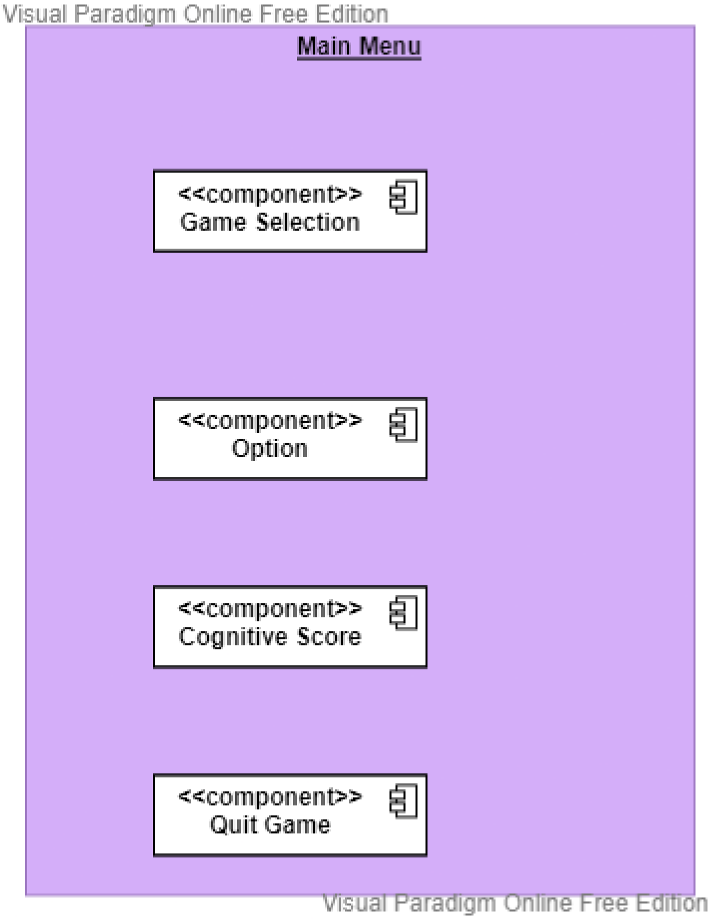


Figure 4.3: Main menu subsystem component diagram

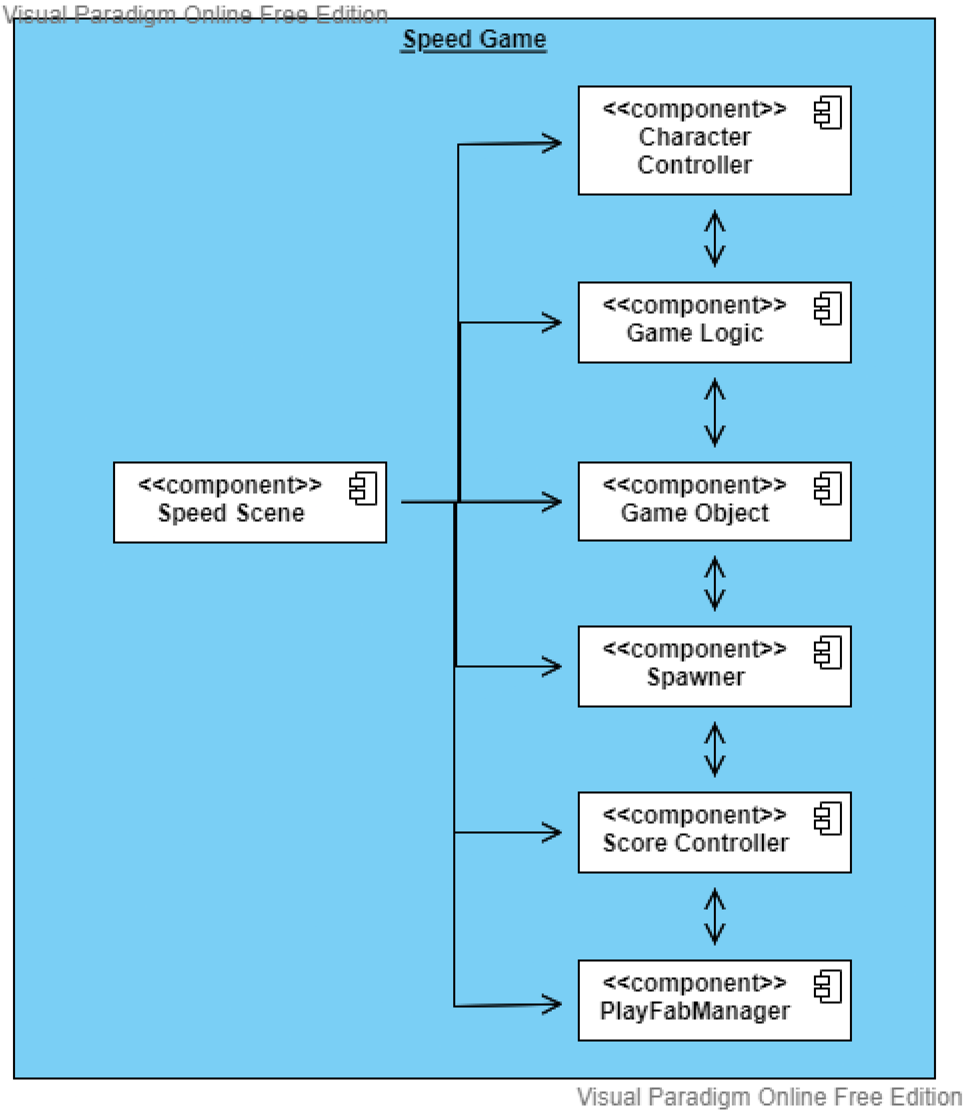

Visual Paradigm Online Free Edition
Speed Game
<<component>> Character Controller
<<component>> Game Logic
<<component>> Speed Scene
<<component>> Game Object
<<component>> Spawner
<<component>> Score Controller
<<component>> PlayFabManager
Visual Paradigm Online Free Edition

Figure 4.4: Speed game subsystem component diagram

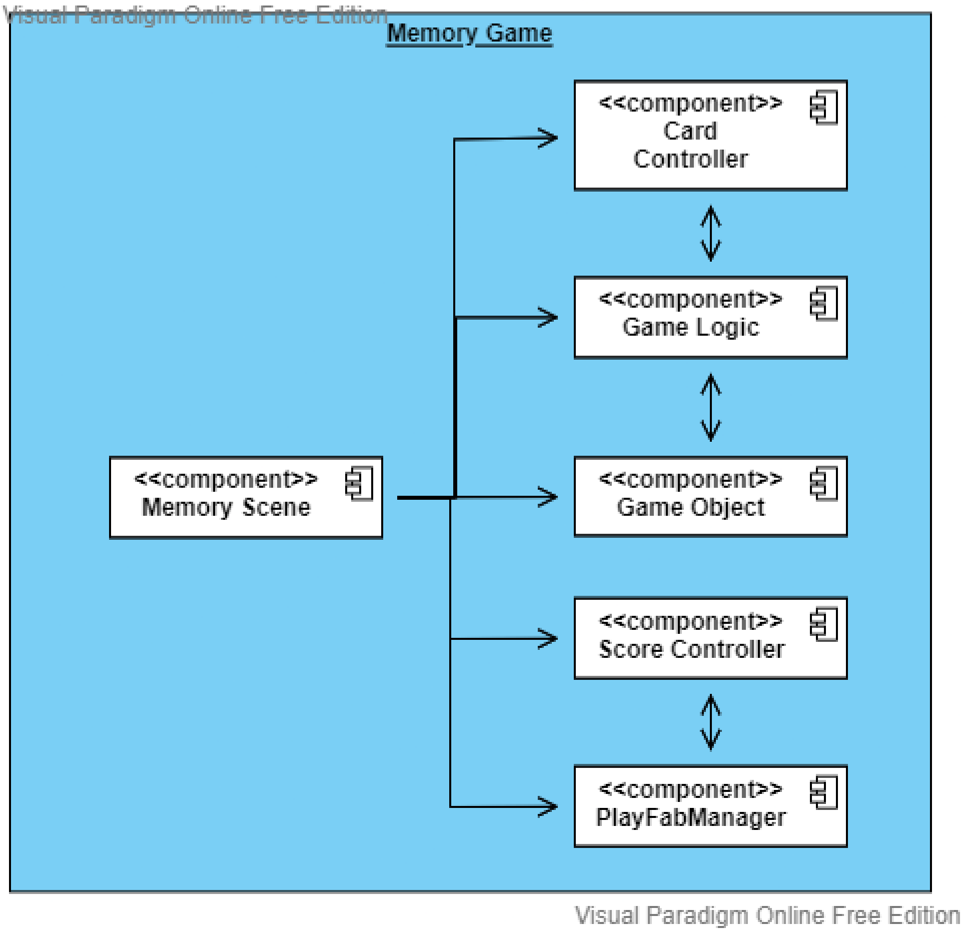

Visual Paradigm Online Free Edition
Memory Game
<<component>> Card Controller
<<component>> Game Logic
<<component>> Memory Scene
<<component>> Game Object
<<component>> Score Controller
<<component>> PlayFabManager
Visual Paradigm Online Free Edition

Figure 4.5: Memory game subsystem component diagram

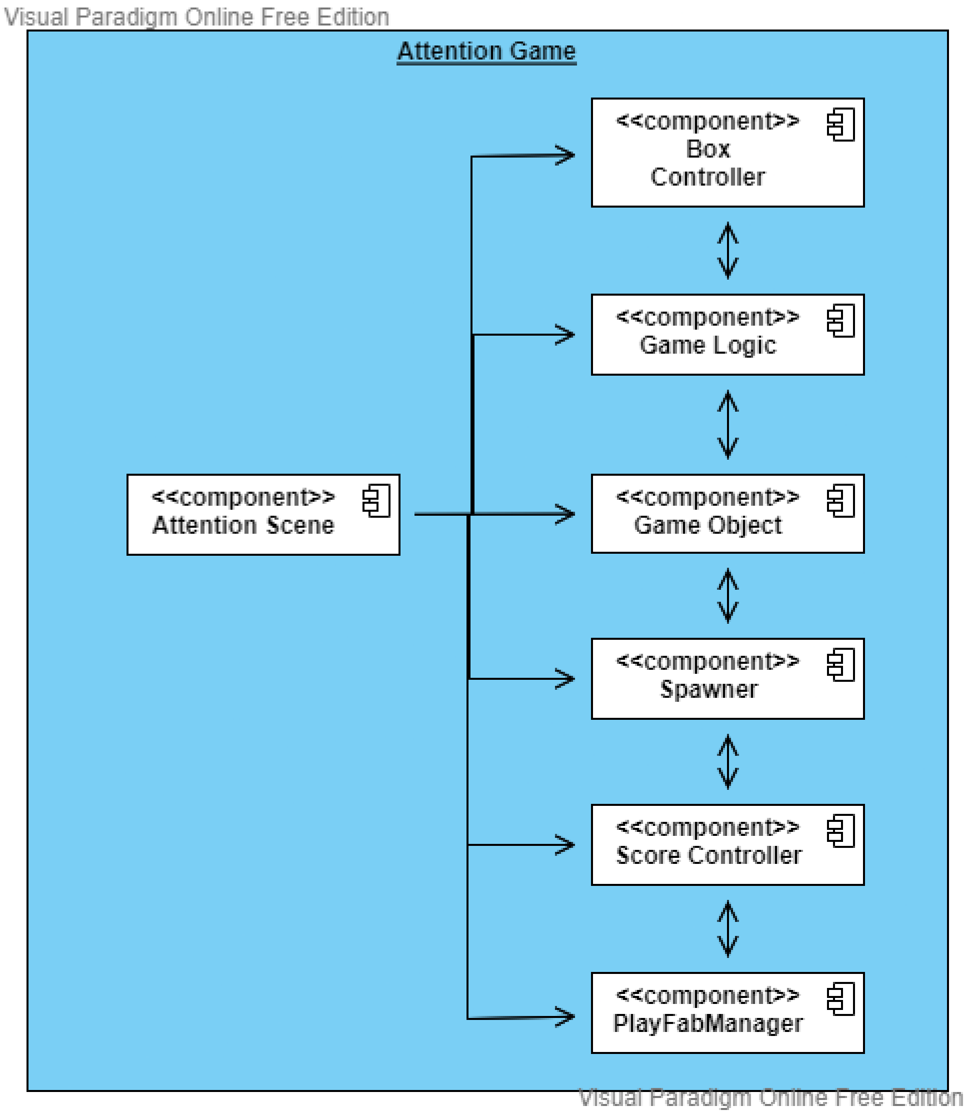

Visual Paradigm Online Free Edition
Attention Game
<<component>> Box Controller
<<component>> Game Logic
<<component>> Attention Scene
<<component>> Game Object
<<component>> Spawner
<<component>> Score Controller
<<component>> PlayFabManager
Visual Paradigm Online Free Edition

Figure 4.6: Attention game subsystem component diagram

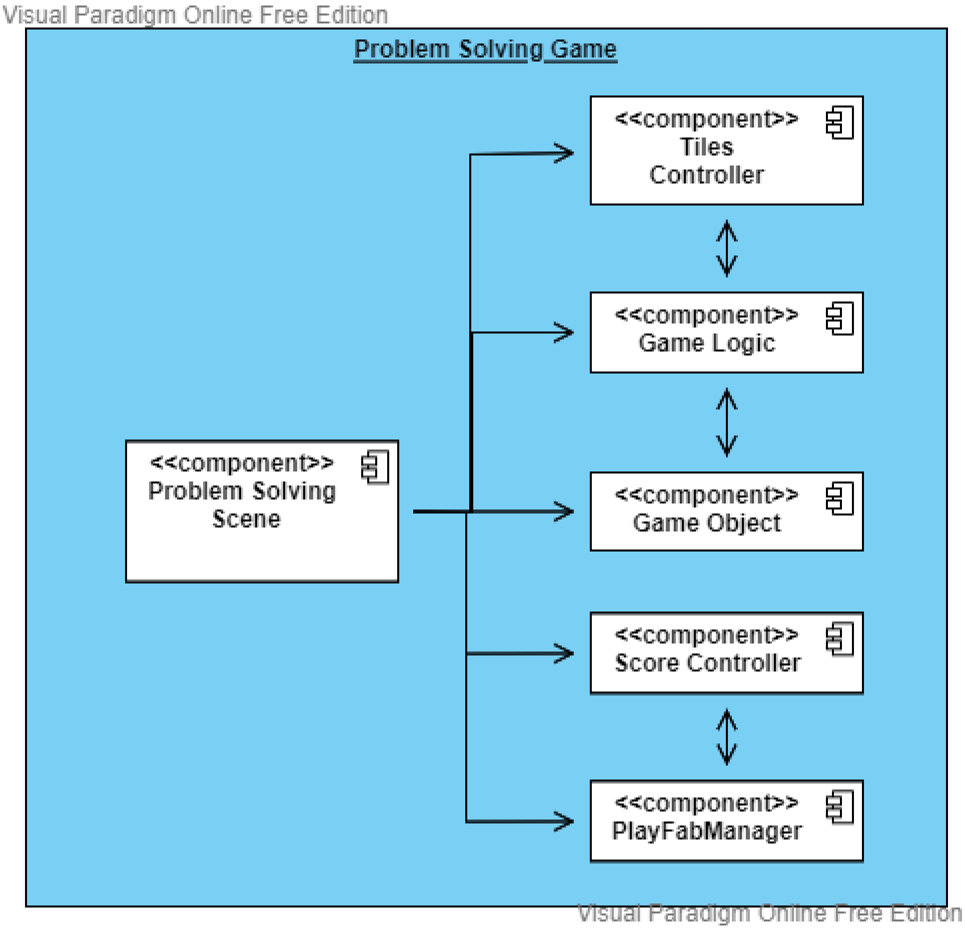

Visual Paradigm Online Free Edition
Problem Solving Game
<<component>> Tiles Controller
<<component>> Game Logic
<<component>> Problem Solving Scene
<<component>> Game Object
<<component>> Score Controller
<<component>> PlayFabManager
Visual Paradigm Online Free Edition

Figure 4.7: Problem solving subsystem component diagram

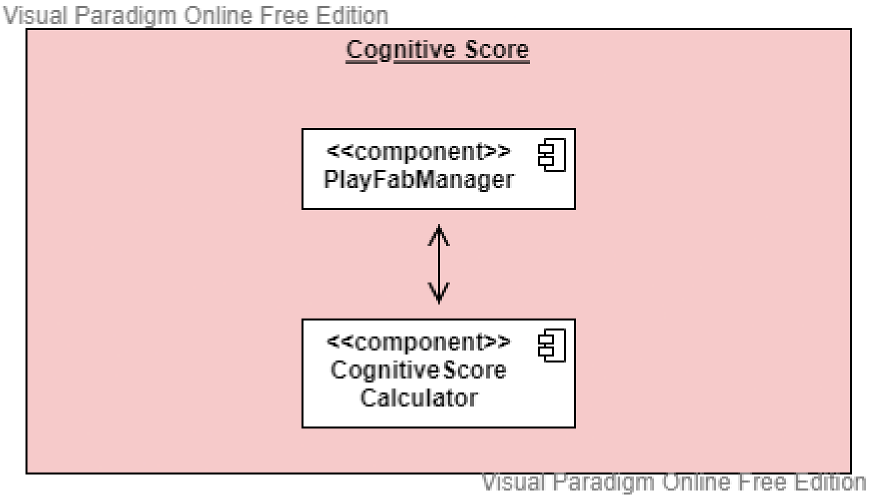

Visual Paradigm Online Free Edition
Cognitive Score
<<component>> PlayFabManager
<<component>> Cognitive Score Calculator
Visual Paradigm Online Free Edition

Figure 4.8: Cognitive score subsystem component diagram

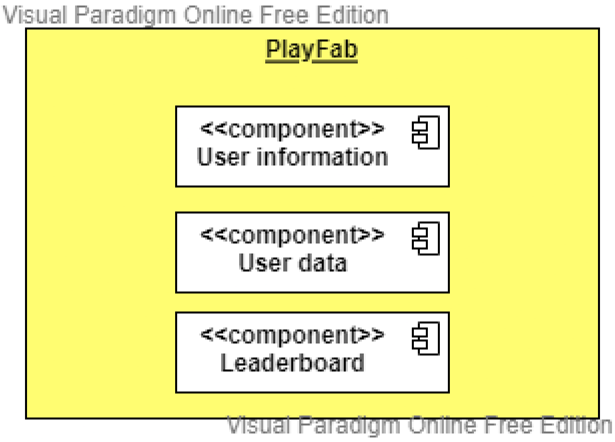


Figure 4.9: PlayFab subsystem component diagram

4.2 Sequence Diagram

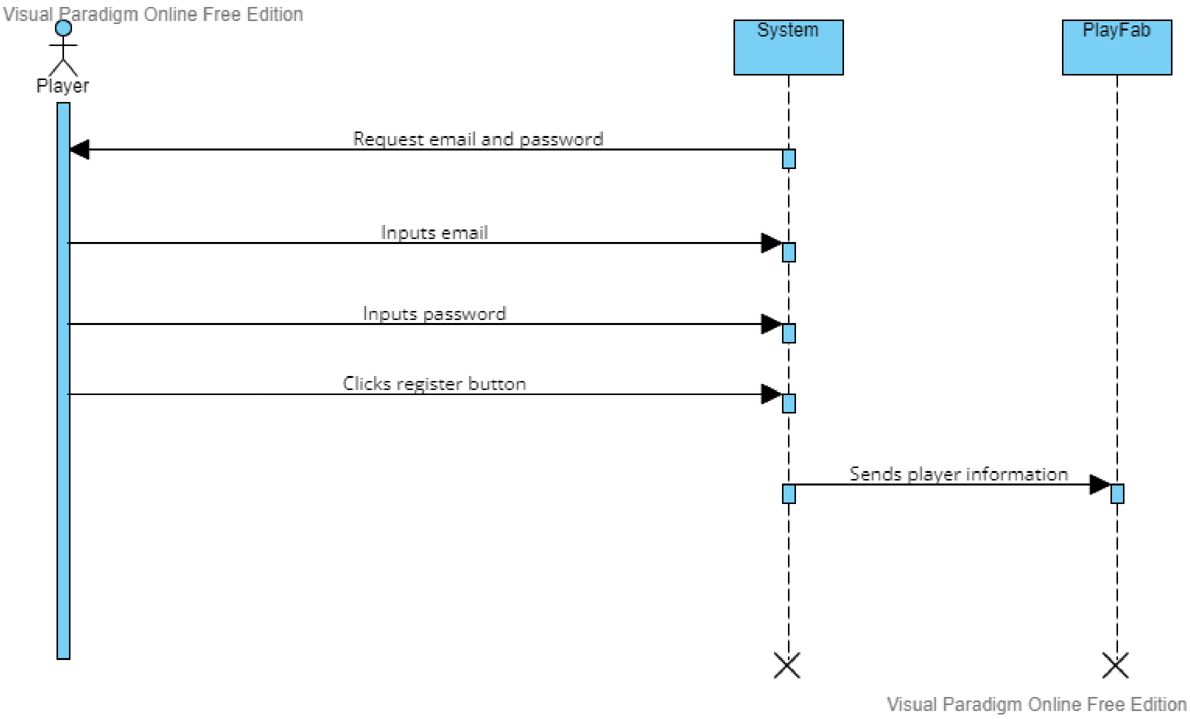

Visual Paradigm Online Free Edition
Player
System
PlayFab
Request email and password
Inputs email
Inputs password
Clicks register button
Sends player information
Visual Paradigm Online Free Edition

Figure 4.10: Register account sequence diagram

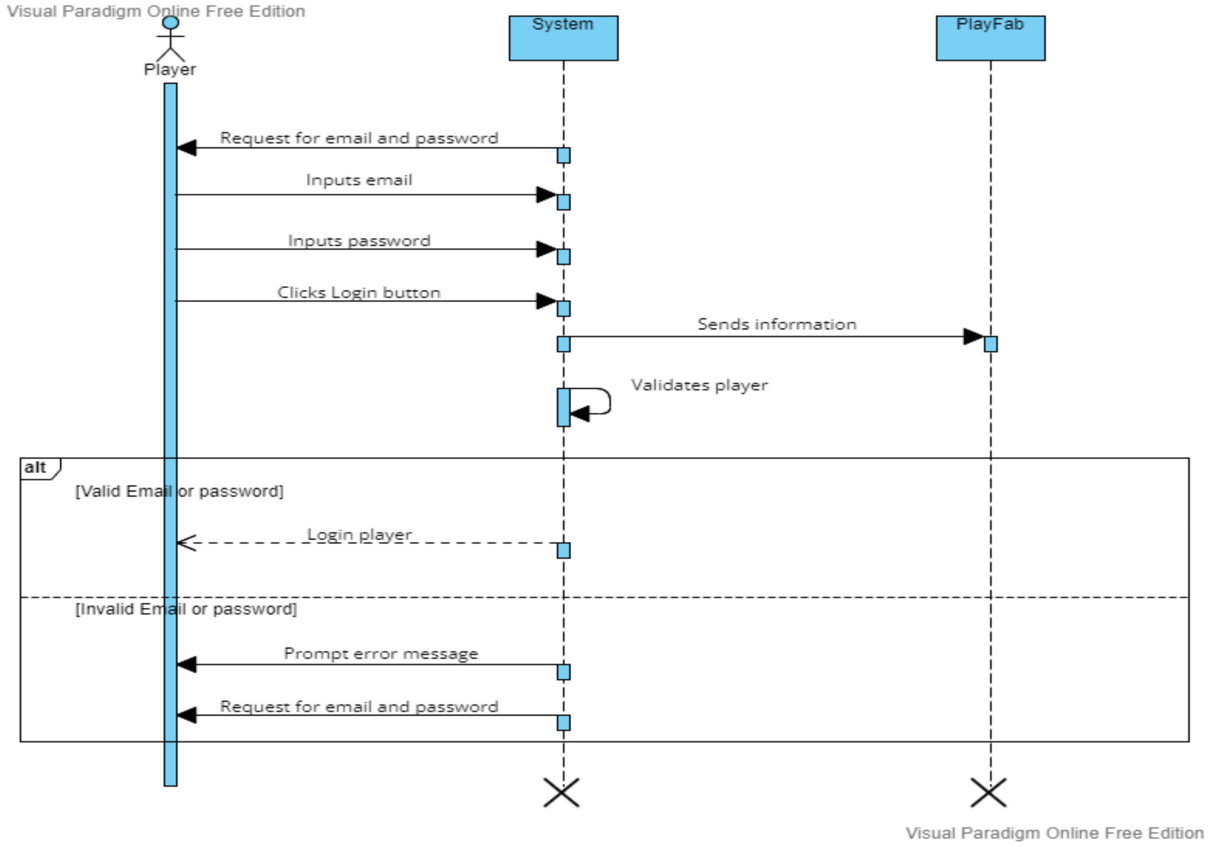

Visual Paradigm Online Free Edition
Player
System
PlayFab
Request for email and password
Inputs email
Inputs password
Clicks Login button
Sends information
Validates player
alt
[Valid Email or password]
Login player
[Invalid Email or password]
Prompt error message
Request for email and password
Visual Paradigm Online Free Edition

Figure 4.11: Login account sequence diagram

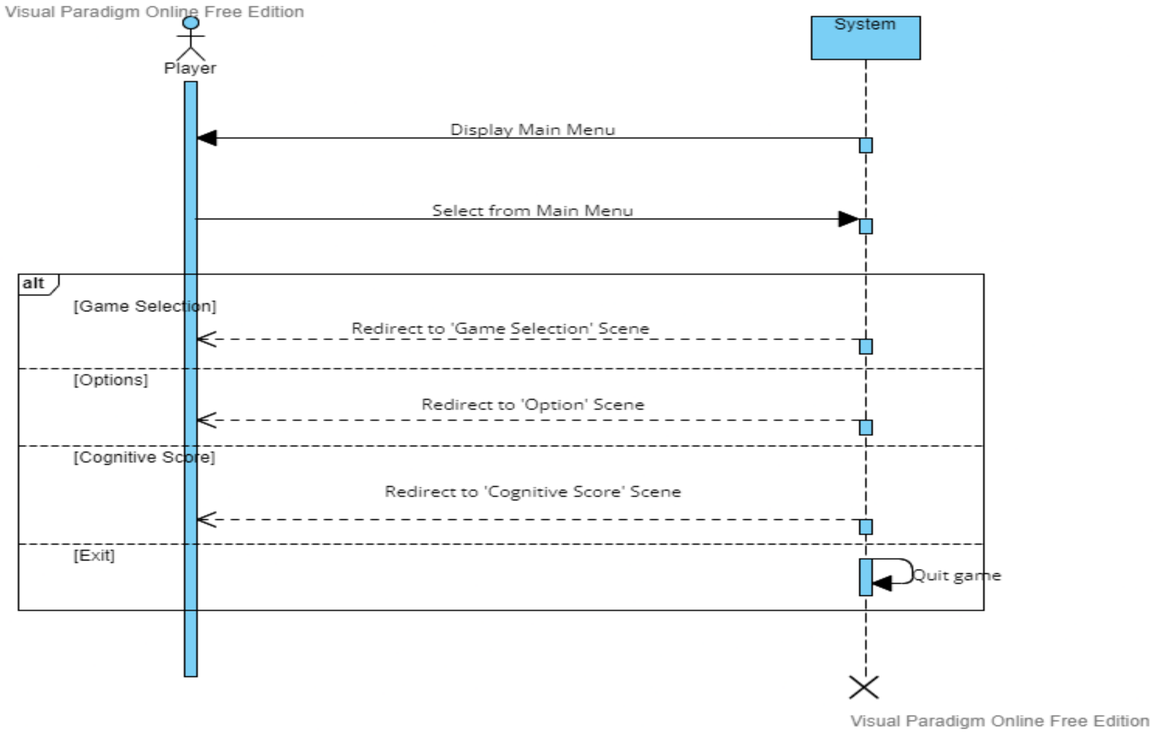

Visual Paradigm Online Free Edition
Player
System
Display Main Menu
Select from Main Menu
alt
[Game Selection]
Redirect to 'Game Selection' Scene
[Options]
Redirect to 'Option' Scene
[Cognitive Score]
Redirect to 'Cognitive Score' Scene
[Exit]
Quit game
Visual Paradigm Online Free Edition

Figure 4.12: Main menu sequence diagram

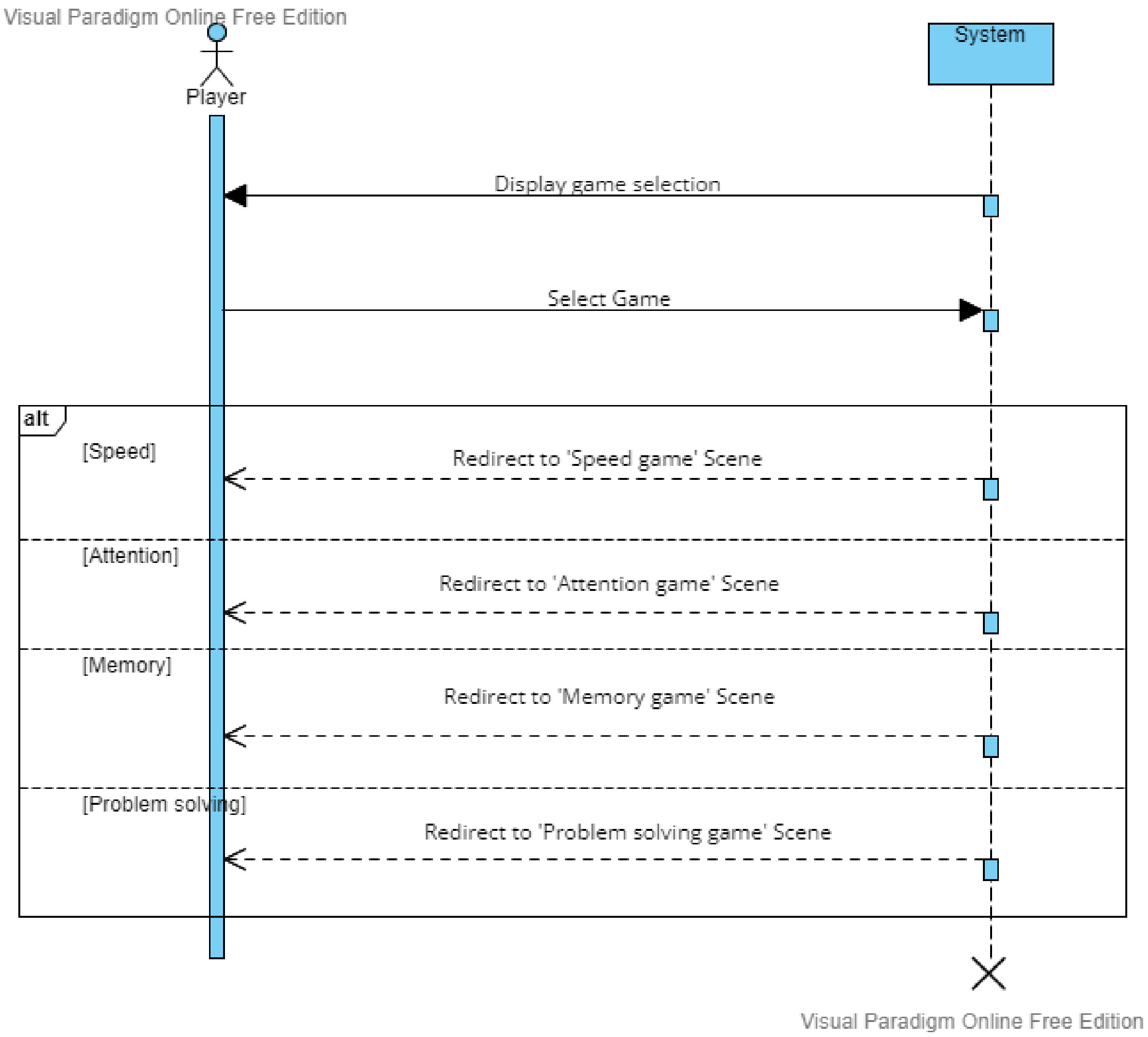

Visual Paradigm Online Free Edition
Player
System
Display game selection
Select Game
alt
[Speed]
Redirect to 'Speed game' Scene
[Attention]
Redirect to 'Attention game' Scene
[Memory]
Redirect to 'Memory game' Scene
[Problem solving]
Redirect to 'Problem solving game' Scene
Visual Paradigm Online Free Edition

Figure 4.13: Game selection sequence diagram

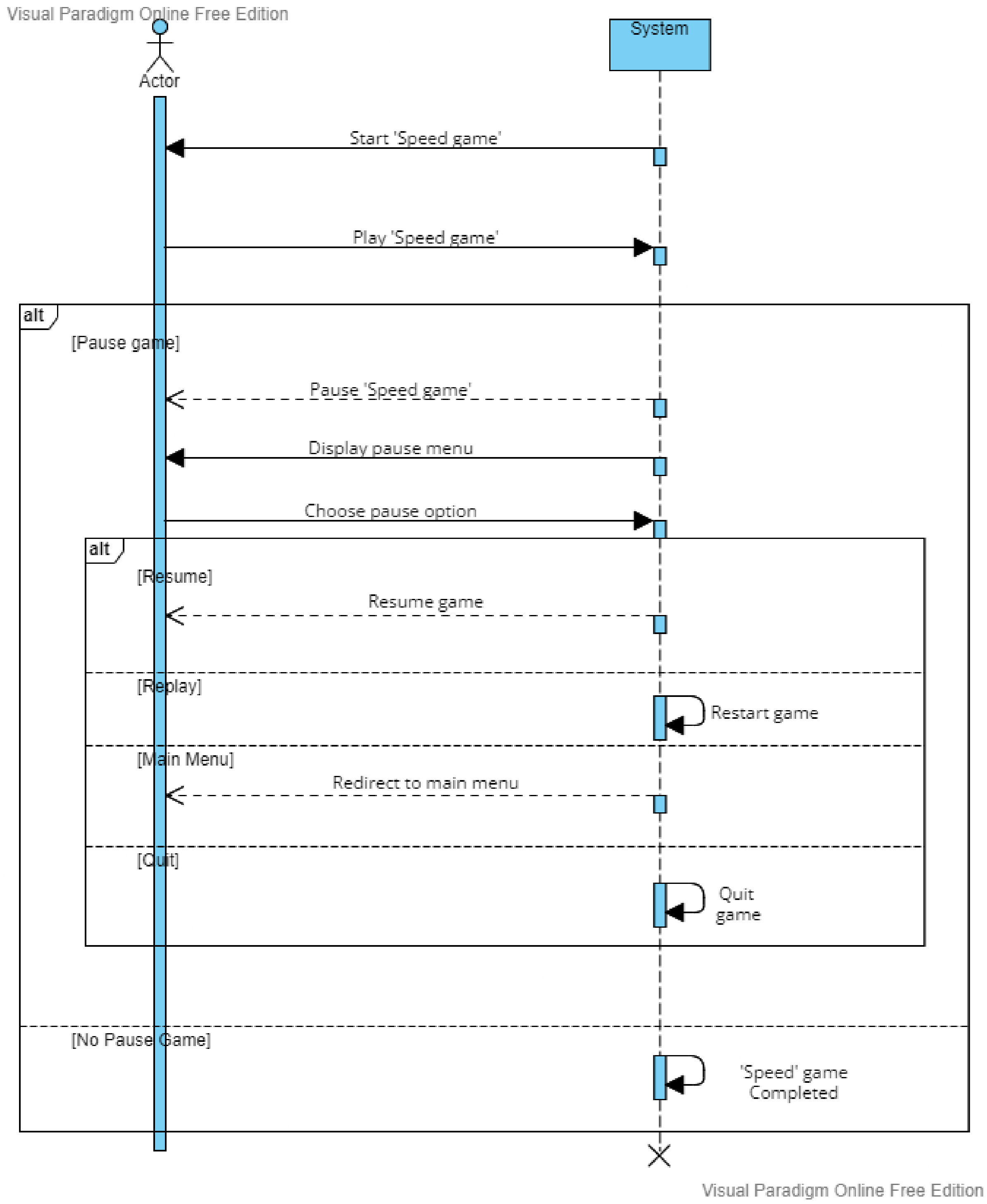


Figure 4.14: Speed game sequence diagram

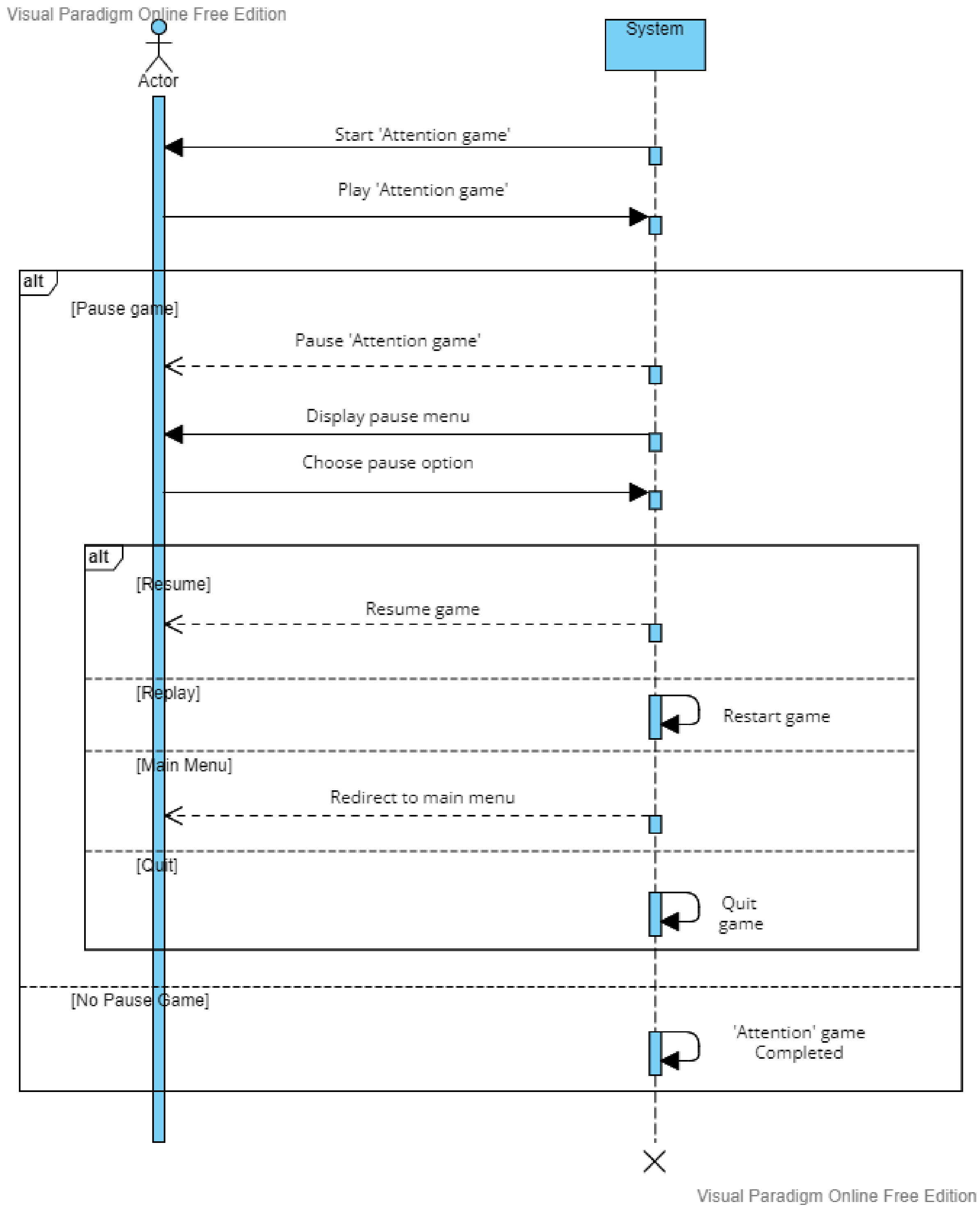


Figure 4.15: Attention game sequence diagram

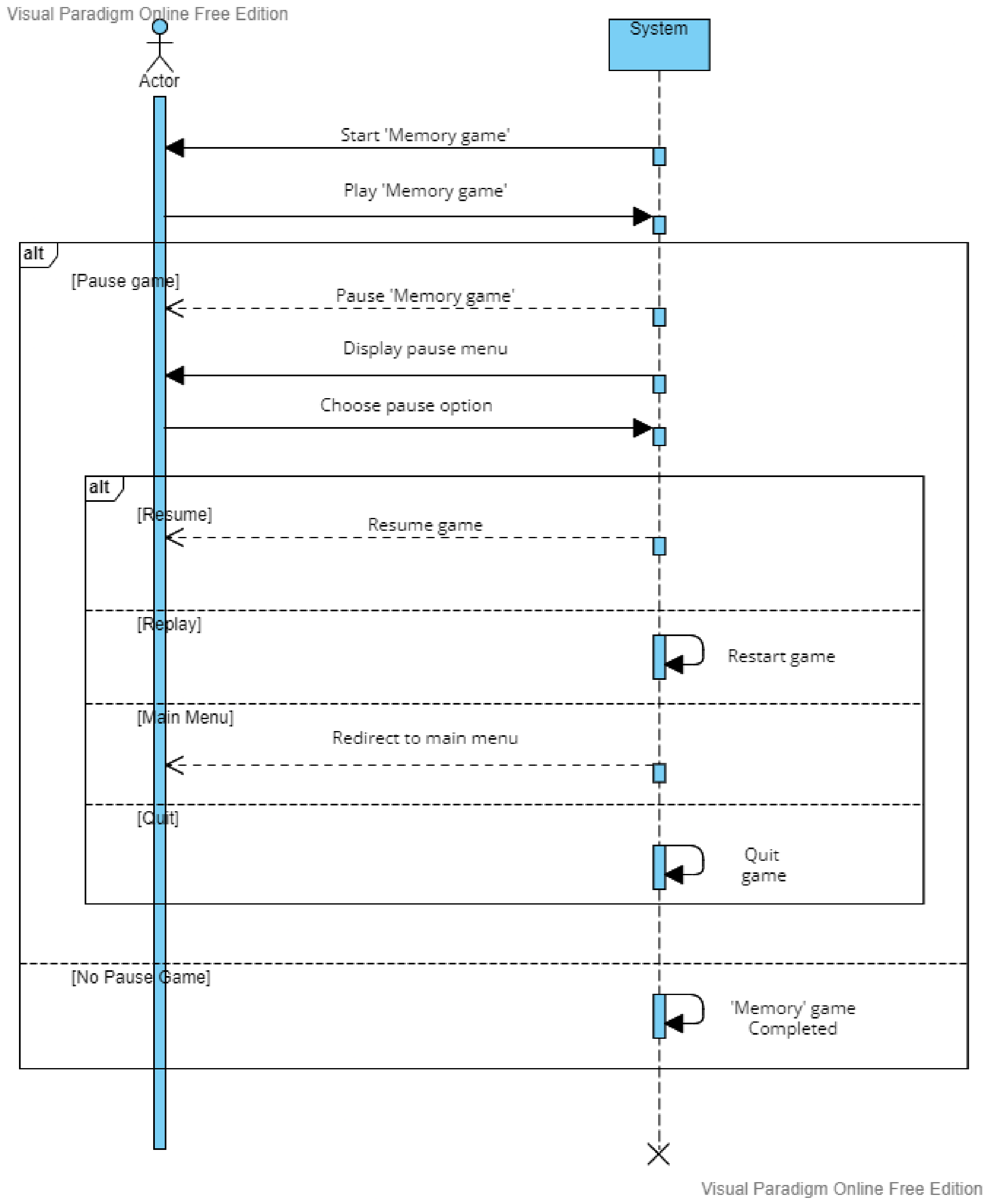


Figure 4.16: Memory game sequence diagram

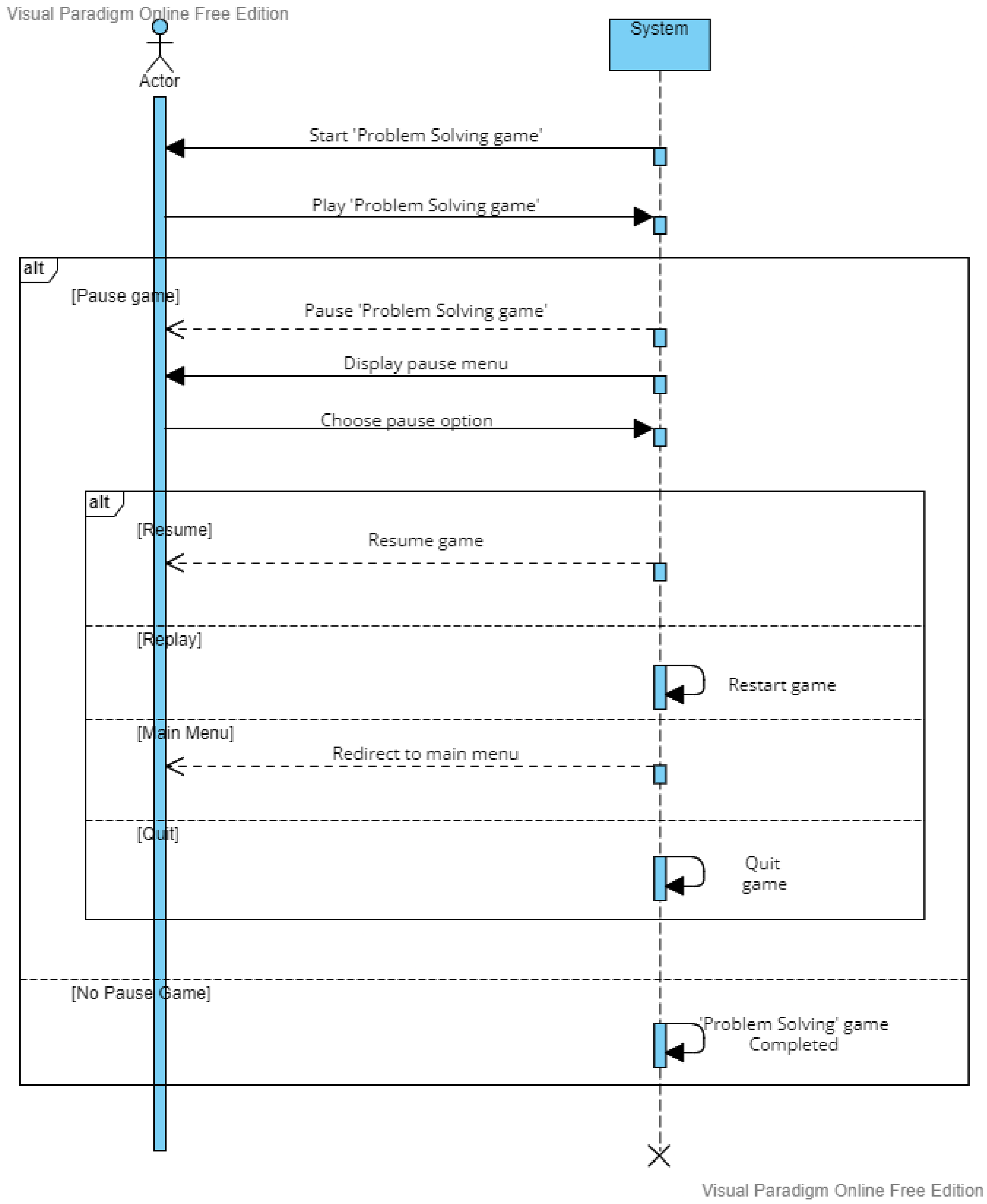

Visual Paradigm Online Free Edition
Actor
System
Start 'Problem Solving game'
Play 'Problem Solving game'
alt
[Pause game]
Pause 'Problem Solving game'
Display pause menu
Choose pause option
alt
[Resume]
Resume game
[Replay]
Restart game
[Main Menu]
Redirect to main menu
[Quit]
Quit game
[No Pause Game]
'Problem Solving' game Completed
Visual Paradigm Online Free Edition

Figure 4.17: Problem solving game sequence diagram

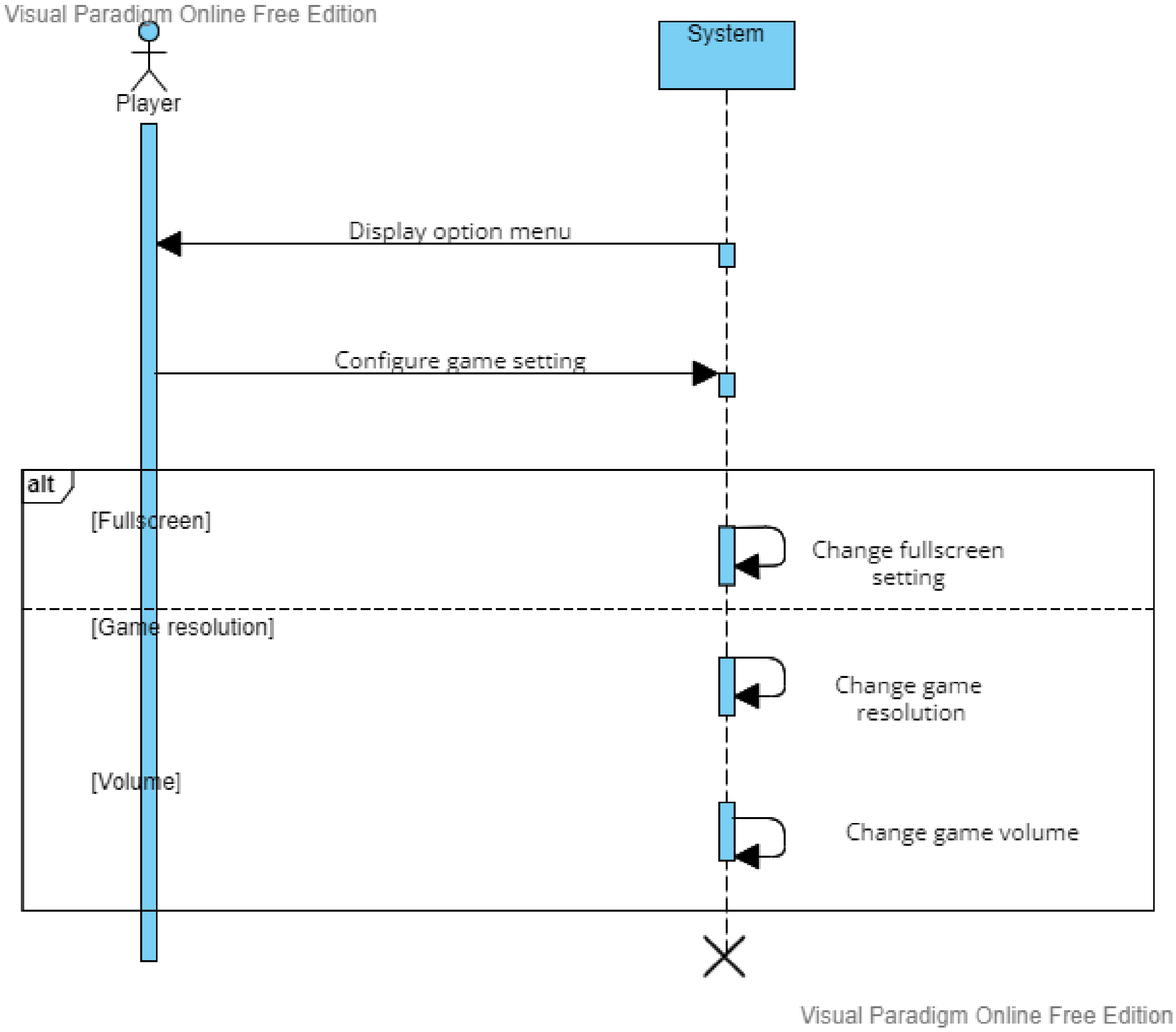


Figure 4.18: Select option sequence diagram

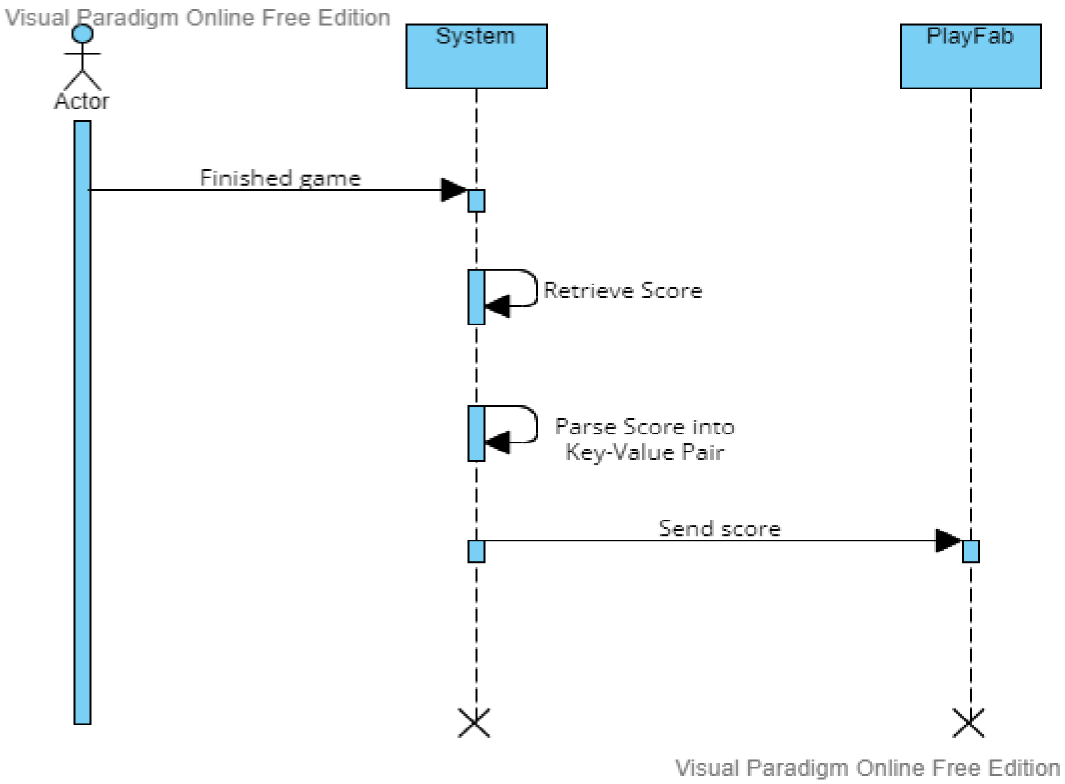

Visual Paradigm Online Free Edition
Actor
System
PlayFab
Finished game
Retrieve Score
Parse Score into Key-Value Pair
Send score
Visual Paradigm Online Free Edition

Figure 4.19: PlayFab send data sequence diagram

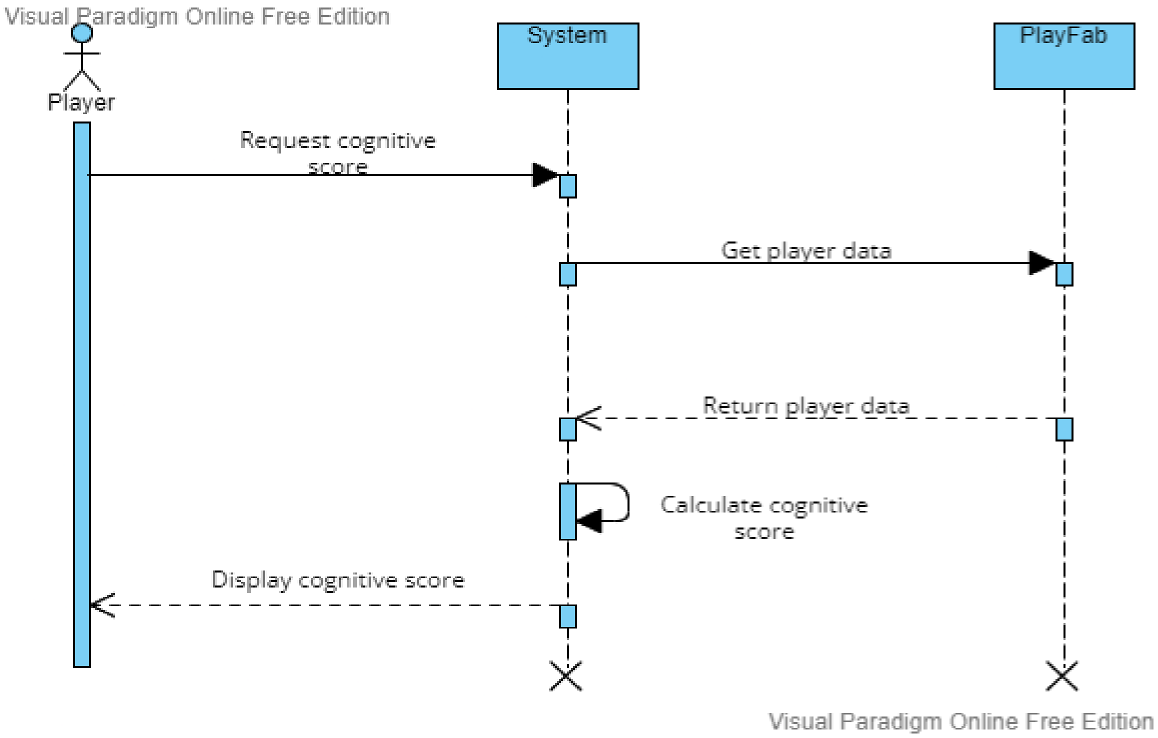


Figure 4.20: Cognitive score sequence diagram

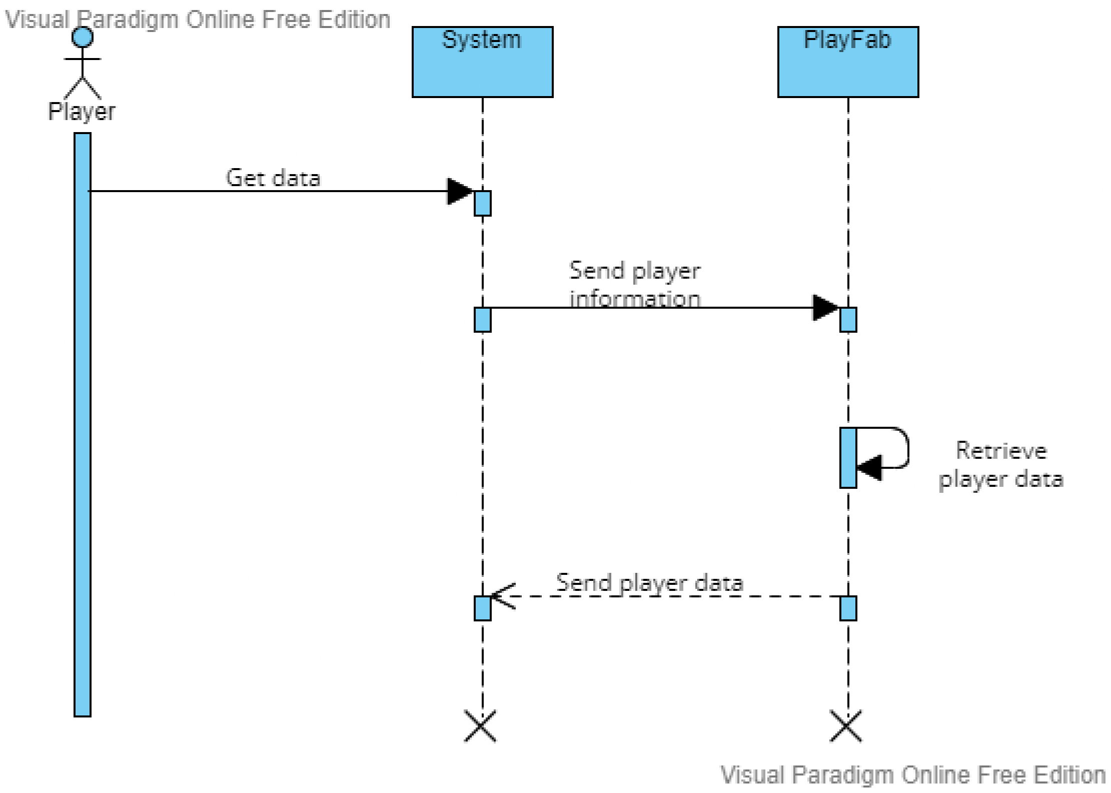


Figure 4.21: PlayFab get data sequence diagram

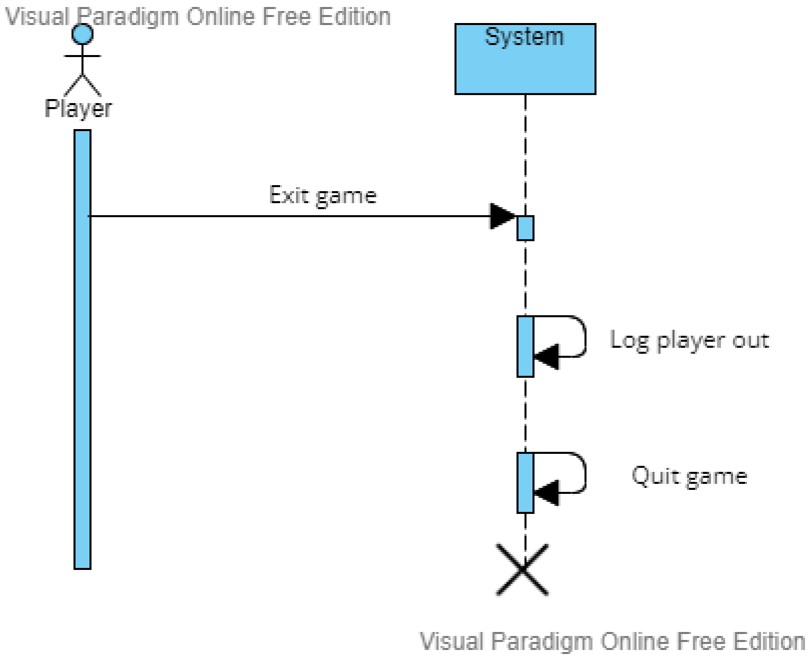

Visual Paradigm Online Free Edition
System
Player
Exit game
Log player out
Quit game
Visual Paradigm Online Free Edition

Figure 4.22: Quit game sequence diagram

4.3 User Interface Design

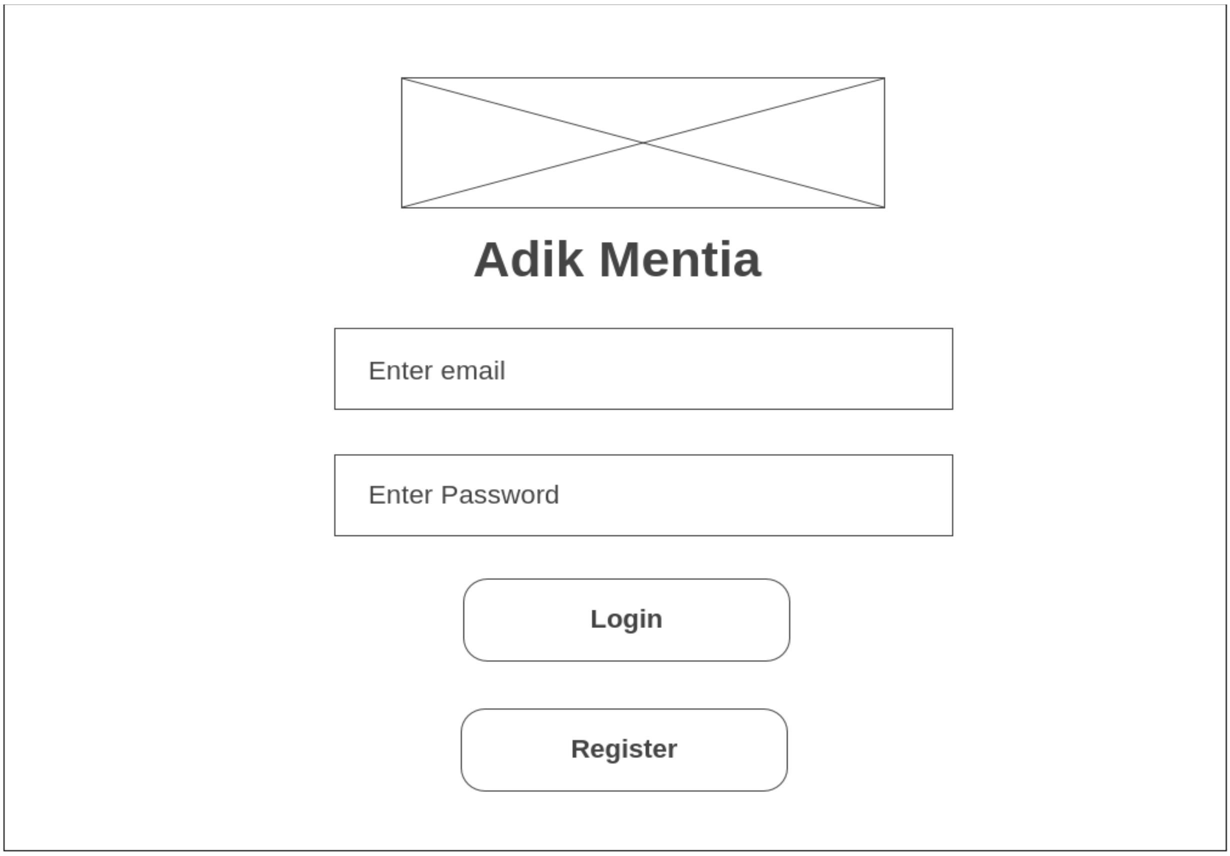


Figure 4.23: Login/Register user interface design

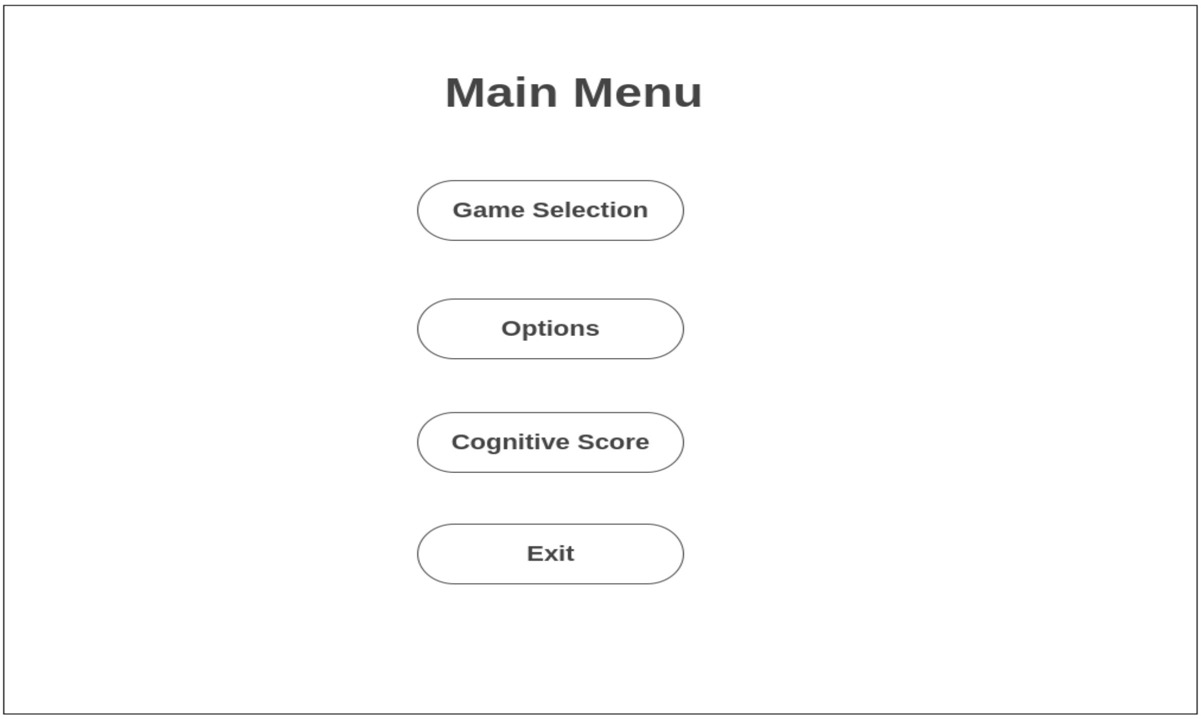


Figure 4.24: Main menu user interface design

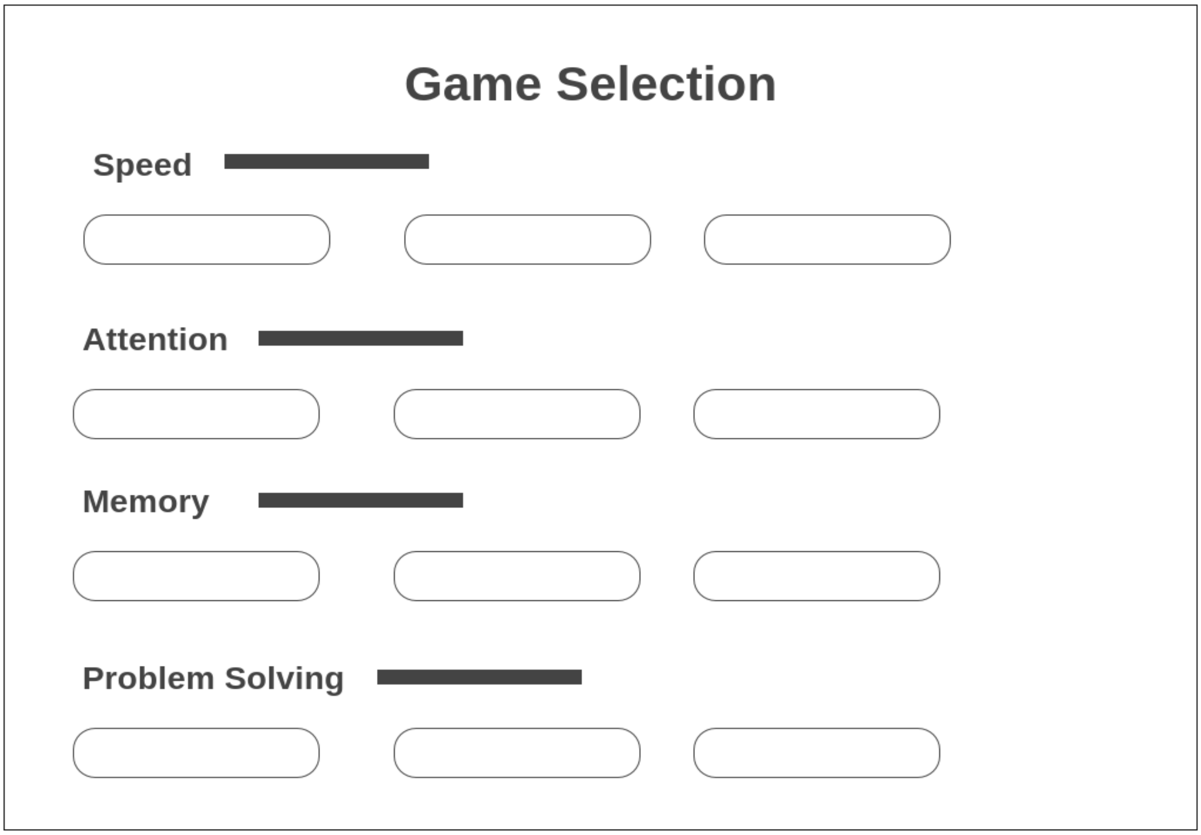


Figure 4.25: Game selection user interface design

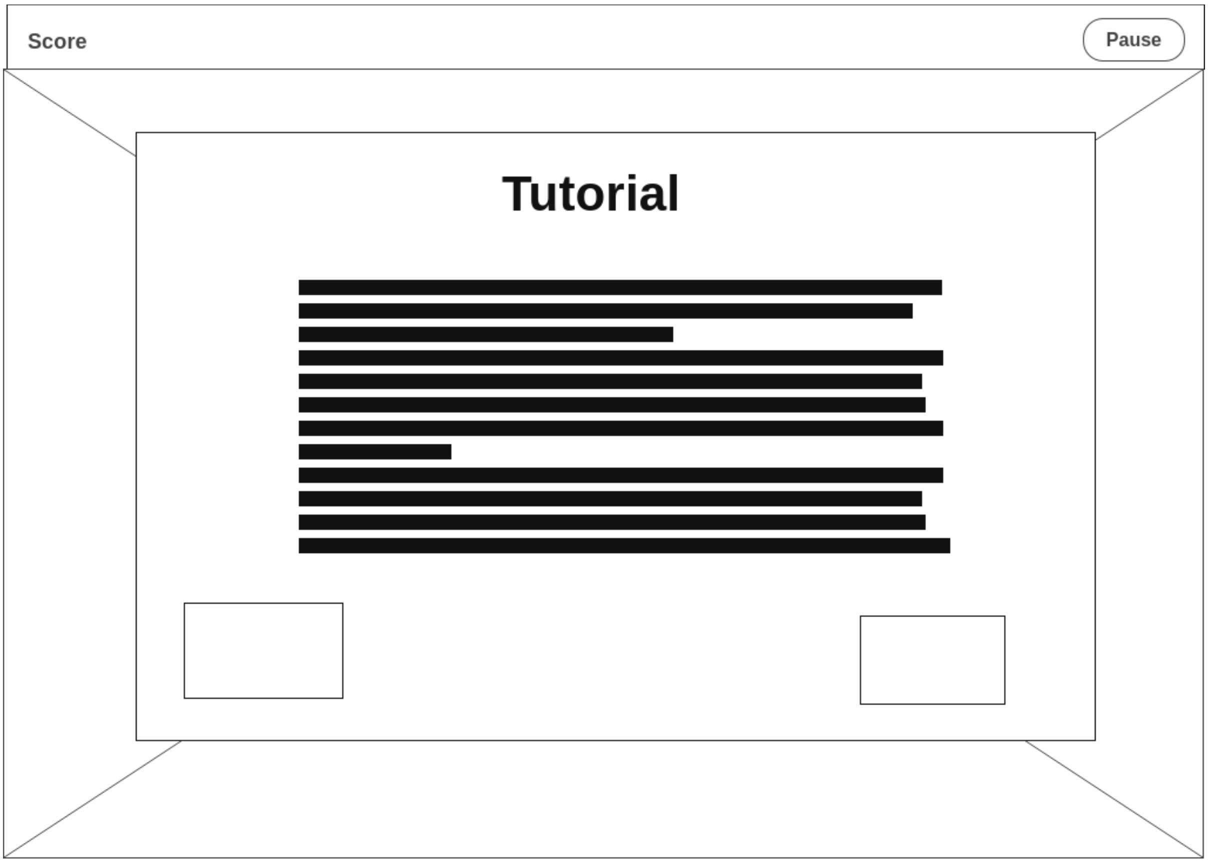


Figure 4.26: Tutorial user interface design

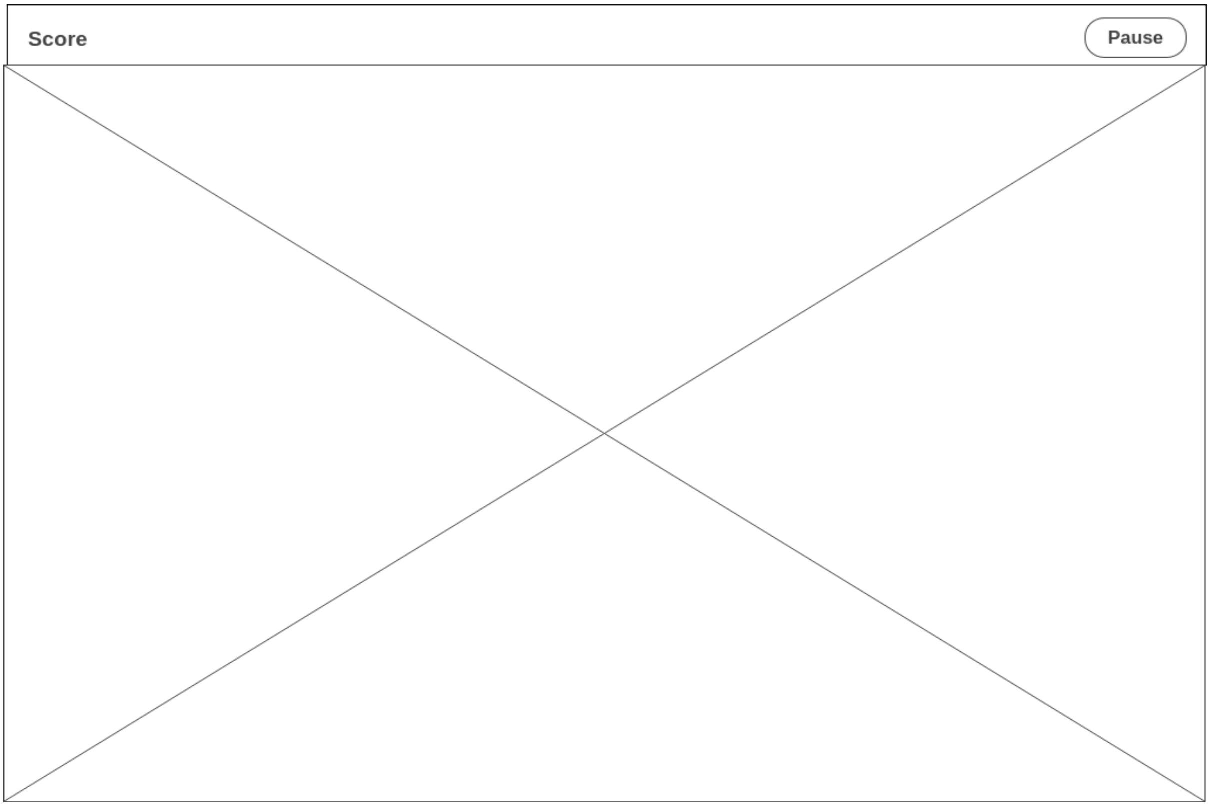


Figure 4.27: Game user interface design

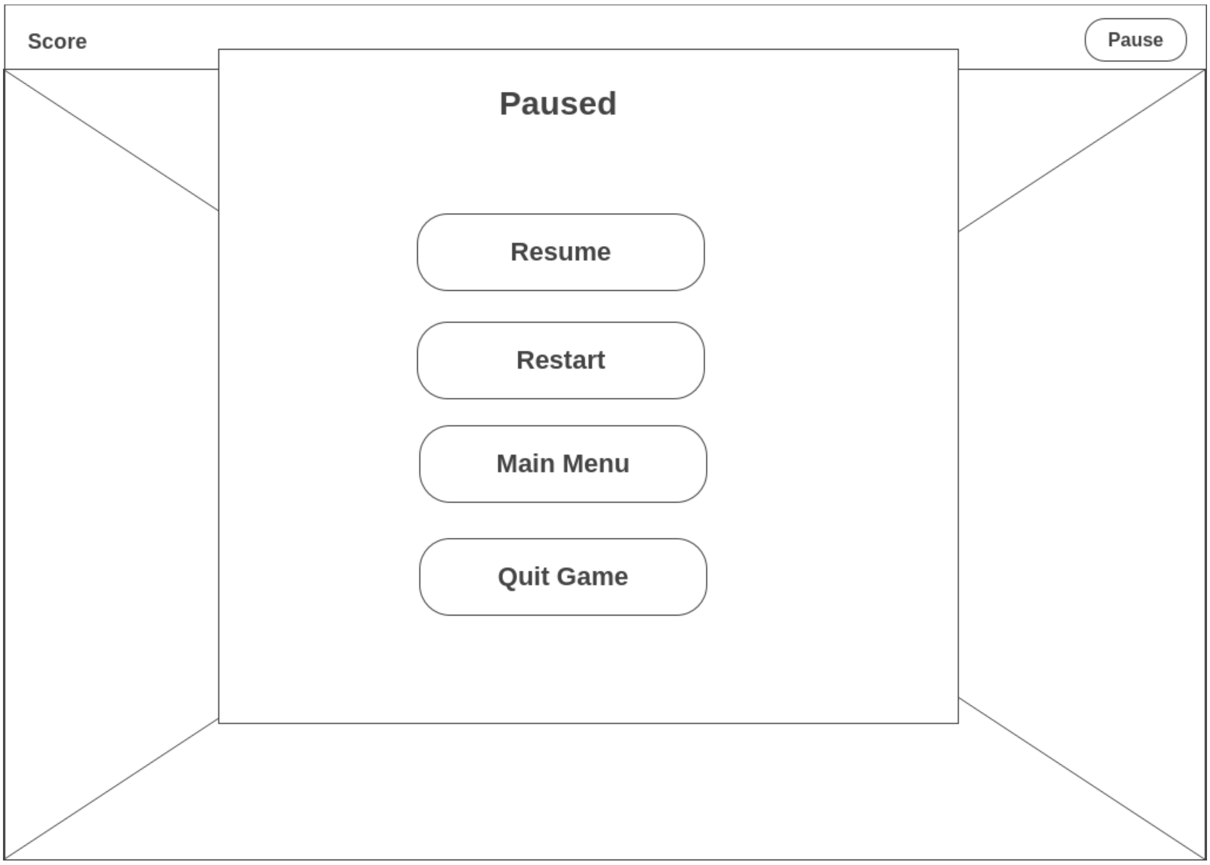


Figure 4.28: Pause game user interface design

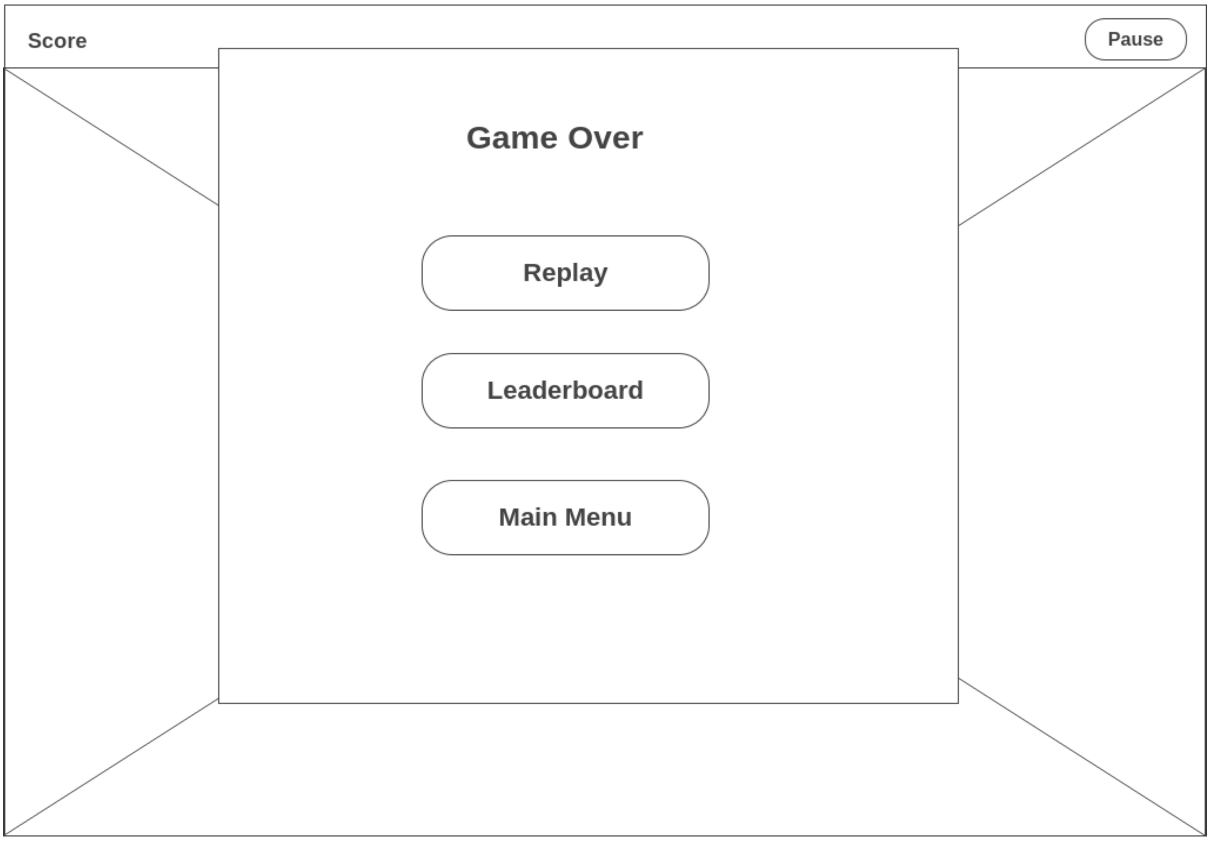


Figure 4.29: Game over user interface design

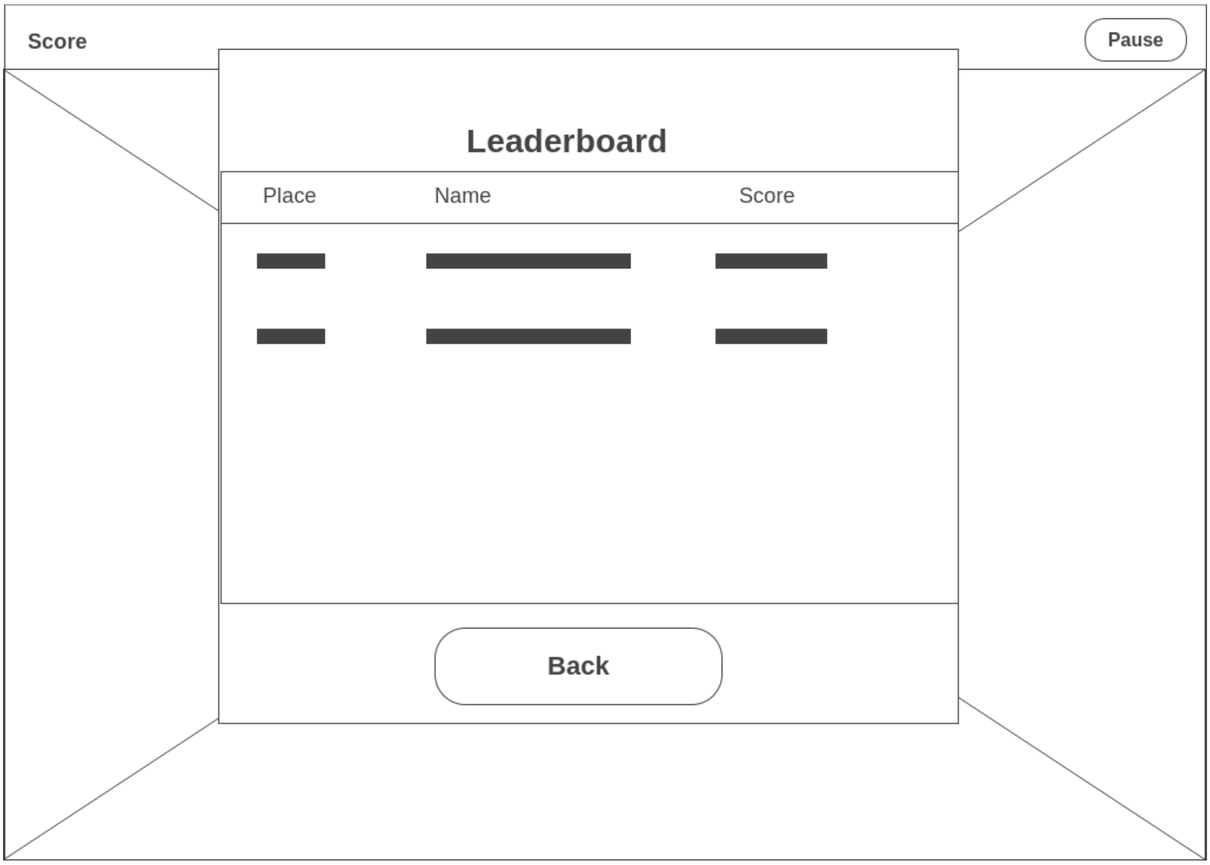
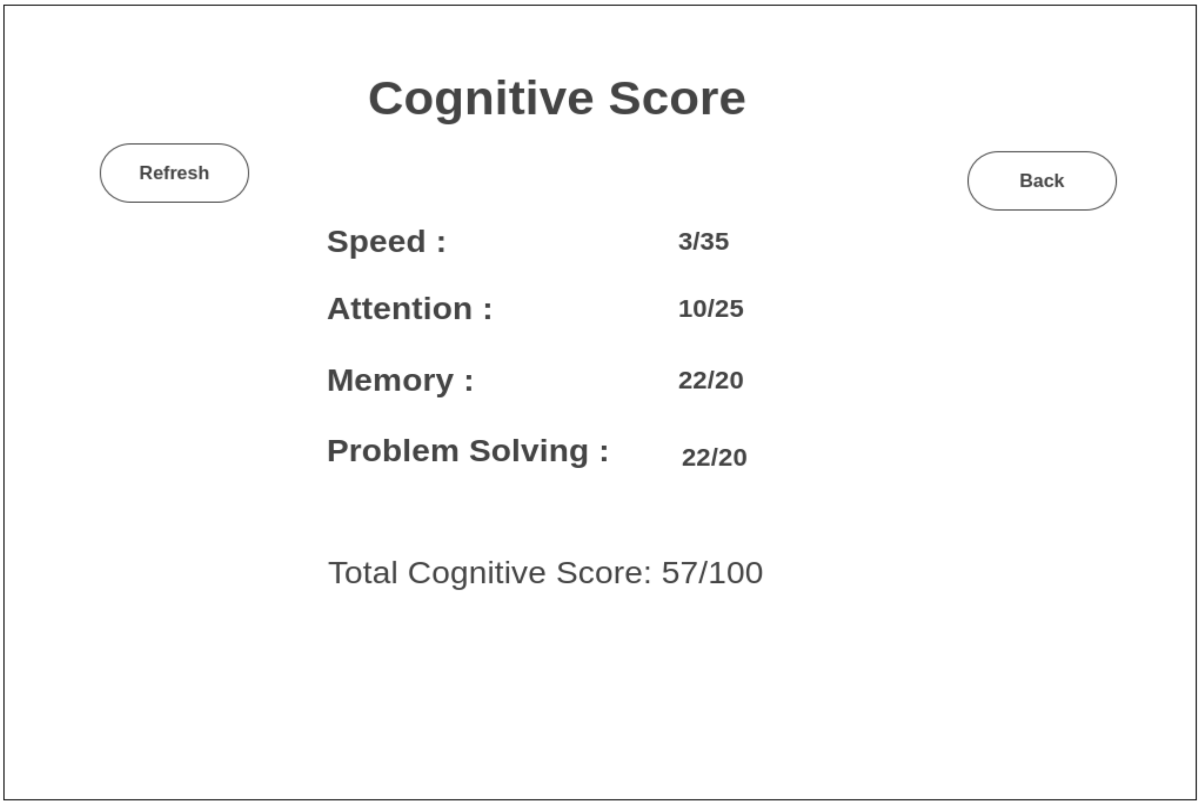


Figure 4.30: Leaderboard user interface design



Speed : 3/35

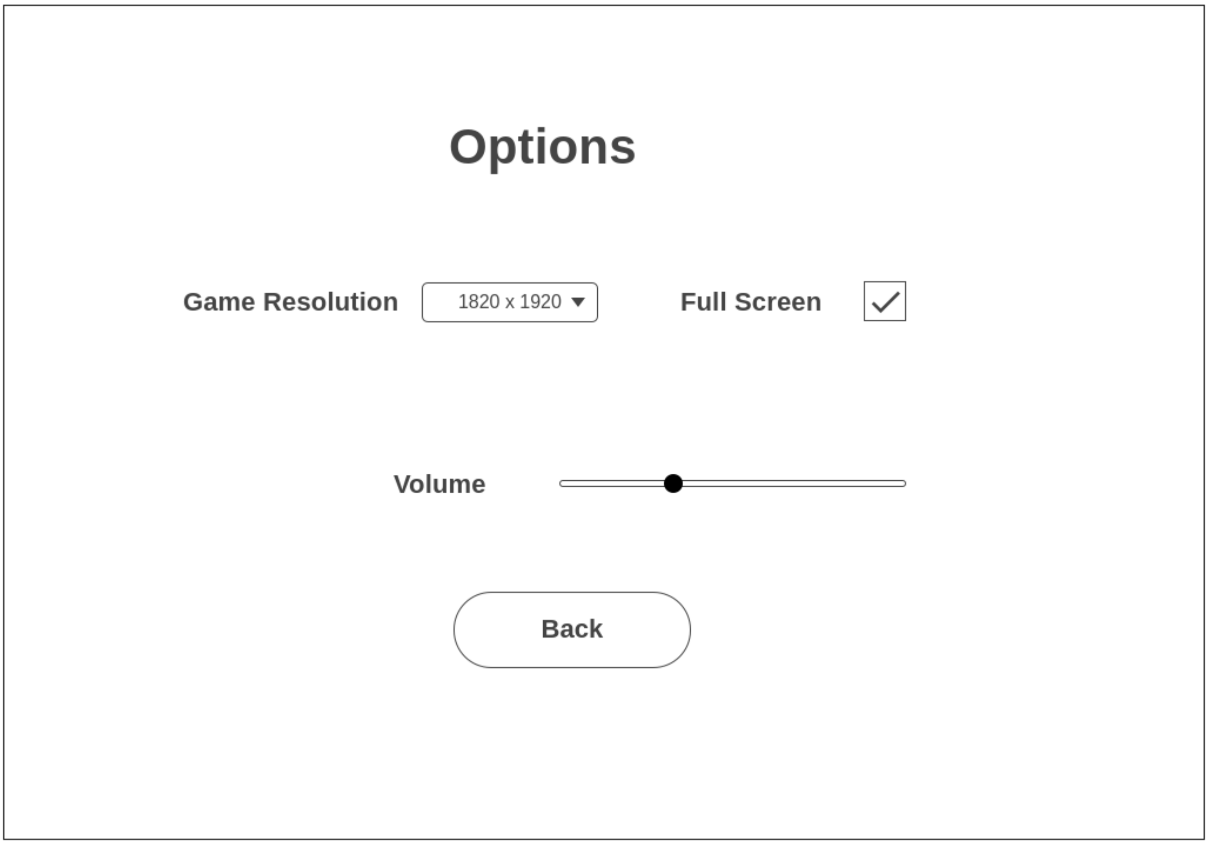
Attention : 10/25

Memory : 22/20

Problem Solving : 22/20

Total Cognitive Score: 57/100

Figure 4.31: Cognitive score user interface design



Game Resolution 1820 x 1920 ▾

Full Screen ☑

Volume

Figure 4.32: Select option user interface design

Chapter 5
System Implementation

5.1 Hardware

Computer

The hardware involved in this project is computer. A computer is used as the hardware tool to design, develop and test the game. The final deliverable will be running on a computer as a computer program.

Description	Specifications
Model	Asus ROG Strix G713
Processor	AMD Ryzen 7 5800H
Operating System	Windows 10
Graphic	NVIDIA GeForce RTX 3050
Memory	8GB DDR4 RAM
Storage	1TB SATA SSD

Table 5.1: Specifications for laptop

5.2 Software

Unity3D

The main platform for the project development will be Unity3D as Unity3D provides a lot of toolkits for game development. The different resources provided by Unity3D such as game scenes, rigidbody, and sound manager makes the game development process easy. The Unity3D also provide Unity Asset Store which consists of all the components needed for game development, such as artwork, 3D models, animation files, and audio.

Figure 5.1: Unity3D Logo

Description	Specifications
Software Name	Unity3D, Unity Hub
Version	2020.3.8f
System type	64-bit

Table 5.2: Specification for Unity3D

Microsoft Visual Studio 2019

The Visual Studio 2019 will be the sub-platform for the game development. The game logic script will be implemented in Microsoft Visual Studio. Microsoft Visual Studio 2019 is a powerful IDE as it provides Microsoft .NET core framework for the game development to use C# Script. Besides, the Visual Studio also provide Unity intelliSense and code navigation to help developer to code faster and accurately in C# scripts. The process of debugging can be done easily in Visual Studio to detect issues occur in the scripts.

Figure 5.2: Microsoft Visual Studio 2019 Logo

Description	Specifications
Software Name	Microsoft Visual Studio
Version	2019
System type	64-bit

Table 5.3: Specifications of Microsoft Visual Studio 2019

Adobe Illustrator 2020

The Adobe Illustrator is used to create sprites for the game model presents in the game. Although Unity Asset Store has a rich collections of game models, the game models for Malaysia themed is very less and insufficient for the game development. Fortunately, the game models can be created in Illustrator and import as sprites into Unity to be used in the game development.

Figure 5.3: Adobe Illustrator Logo

Description	Specifications
Software Name	Adobe Illustrator
Version	2020
System type	64-bit

Table 5.4: Specifications of Adobe Illustrator

Microsoft Azure PlayFab

PlayFab is chosen as the cloud provider of the project. PlayFab is a backend platform for live games with managed game services and game analytics. PlayFab will be used for user's information and data storage, authentication, leaderboard and registration.

Figure 5.4: PlayFab Logo

Description	Specifications
Software Name	Adobe Illustrator
System type	Cloud provider

Table 5.5: Specifications of PlayFab

5.3 Setting and Configuration

Setting up Unity

1. Install UnityHub and get the Unity versions required.

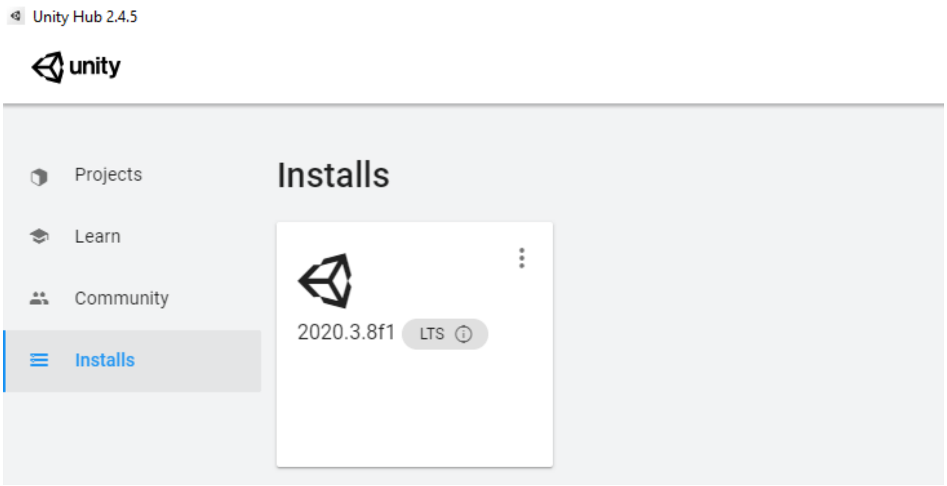


Figure 5.5: Unity Hub

2. Create a Project.

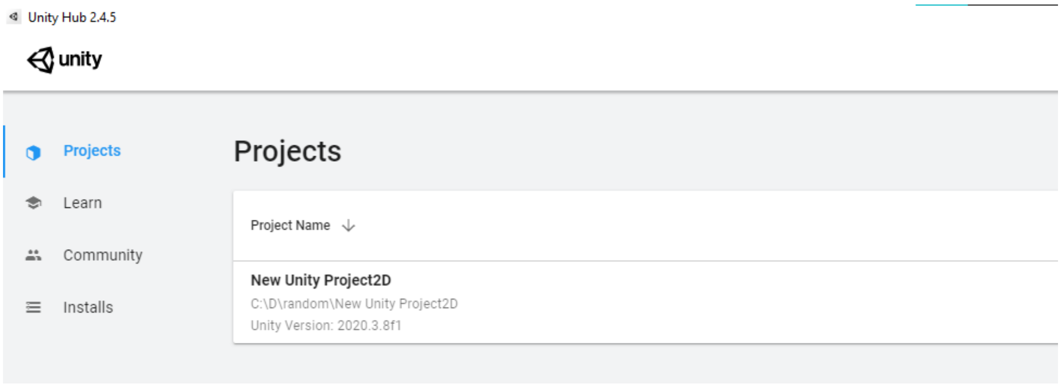
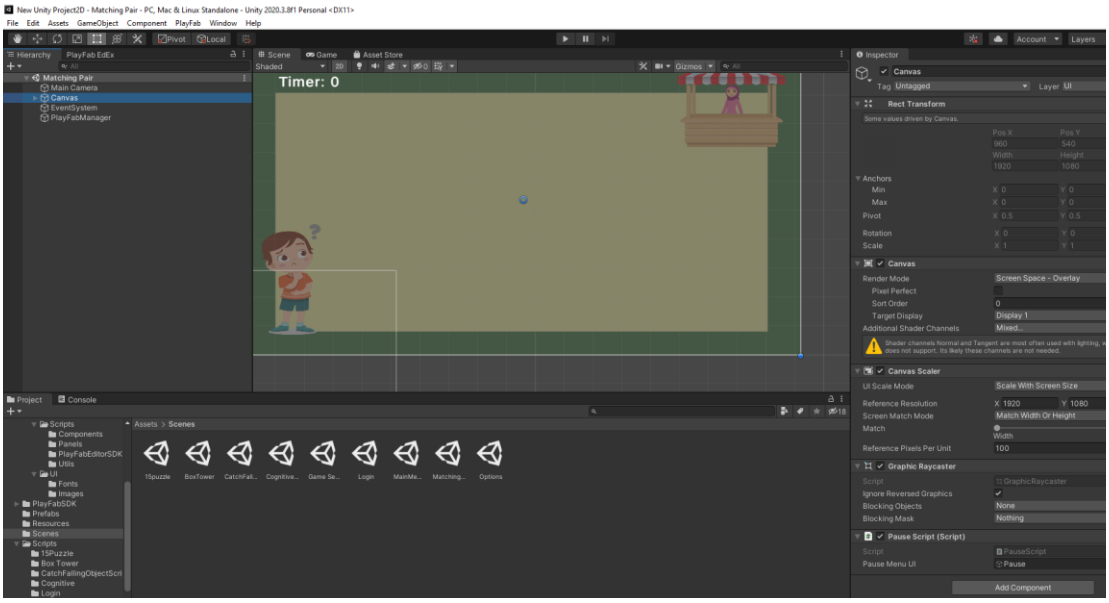


Figure 5.6: Unity Hub project directory

3. Project created successfully.



Canvas
Tag Untagged
Layer UI

Rect Transform
Some values driven by Canvas.
Pos X 960
Pos Y 540
Width 1920
Height 1080
Anchors
Min X 0 Y 0
Max X 0 Y 0
Pivot X 0.5 Y 0.5
Rotation X 0 Y 0
Scale X 1 Y 1

Canvas
Render Mode: Screen Space - Overlay
Pixel Perfect: ☐
Sort Order: 0
Target Display: Display 1
Additional Shader Channels: Mixed...
Shader channels Normal and Tangent are most often used with lighting, w... does not support. Its likely these channels are not needed.

Canvas Scaler
UI Scale Mode: Scale With Screen Size
Reference Resolution: X 1920 Y 1080
Screen Match Mode: Match Width Or Height
Match: Width
Reference Pixels Per Unit: 100

Graphic Raycaster
Script: GraphicRaycaster
Ignore Reversed Graphics: ✓
Blocking Objects: None
Blocking Mask: Nothing

Pause Script (Script)
Script: PauseScript
Pause Menu UI: Pause

Figure 5.7: Unity3D working space

Setting up Microsoft Visual Studio

1. Install Microsoft Visual Studio 2019.

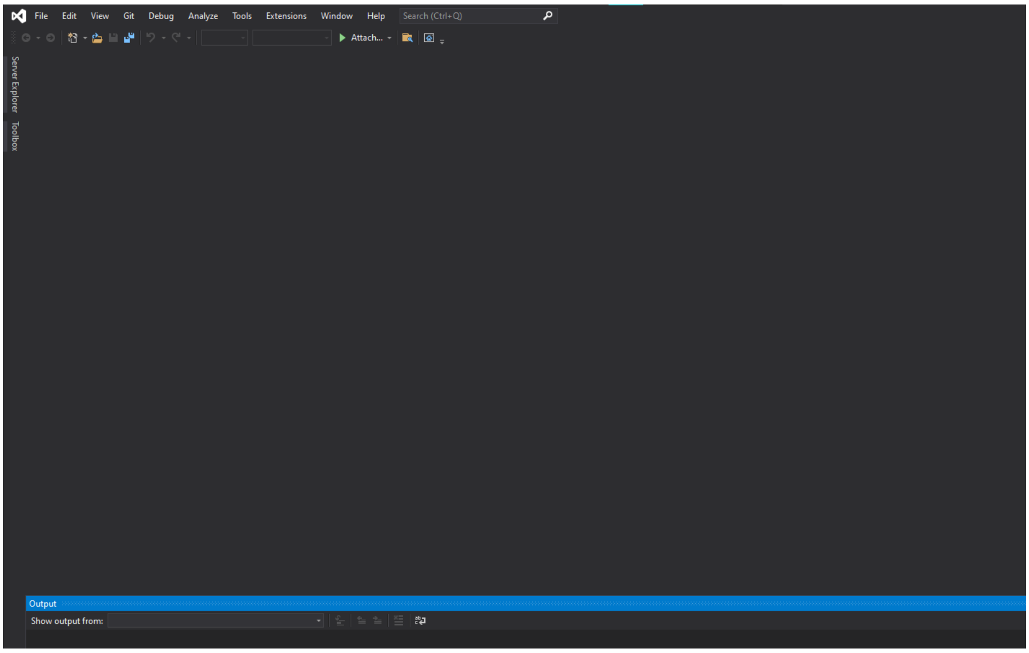
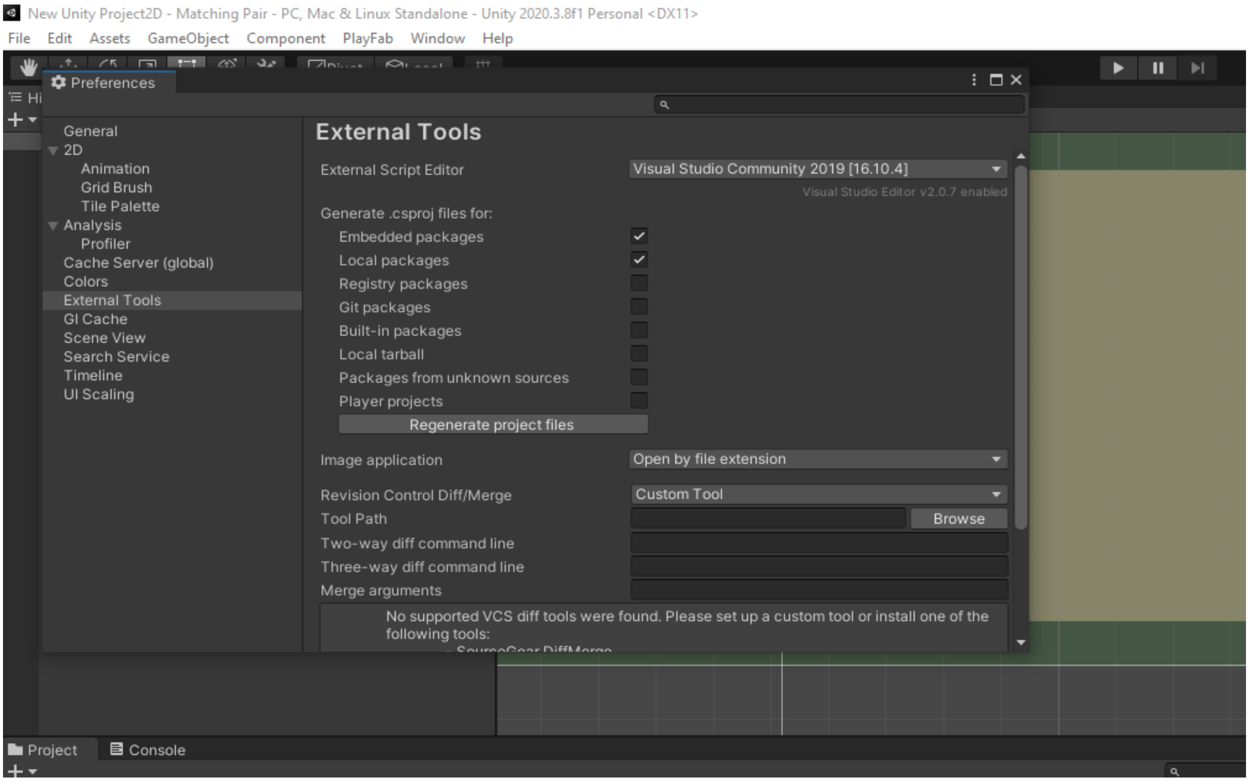


Figure 5.8: Microsoft Visual Studio IDE

2. Go to Unity3D > Edit > Preference > External Tools and choose Microsoft Visual Studio as the External Script Tools.


New Unity Project2D - Matching Pair - PC, Mac & Linux Standalone - Unity 2020.3.8f1 Personal <DX11>

Preferences

External Tools

External Script Editor: Visual Studio Community 2019 [16.10.4]

Visual Studio Editor v2.0.7 enabled

Generate .csproj files for:
- ☑ Embedded packages
- ☑ Local packages
- □ Registry packages
- □ Git packages
- □ Built-in packages
- □ Local tarball
- □ Packages from unknown sources
- □ Player projects

Image application: Open by file extension

Revision Control Diff/Merge: Custom Tool

Tool Path

Two-way diff command line

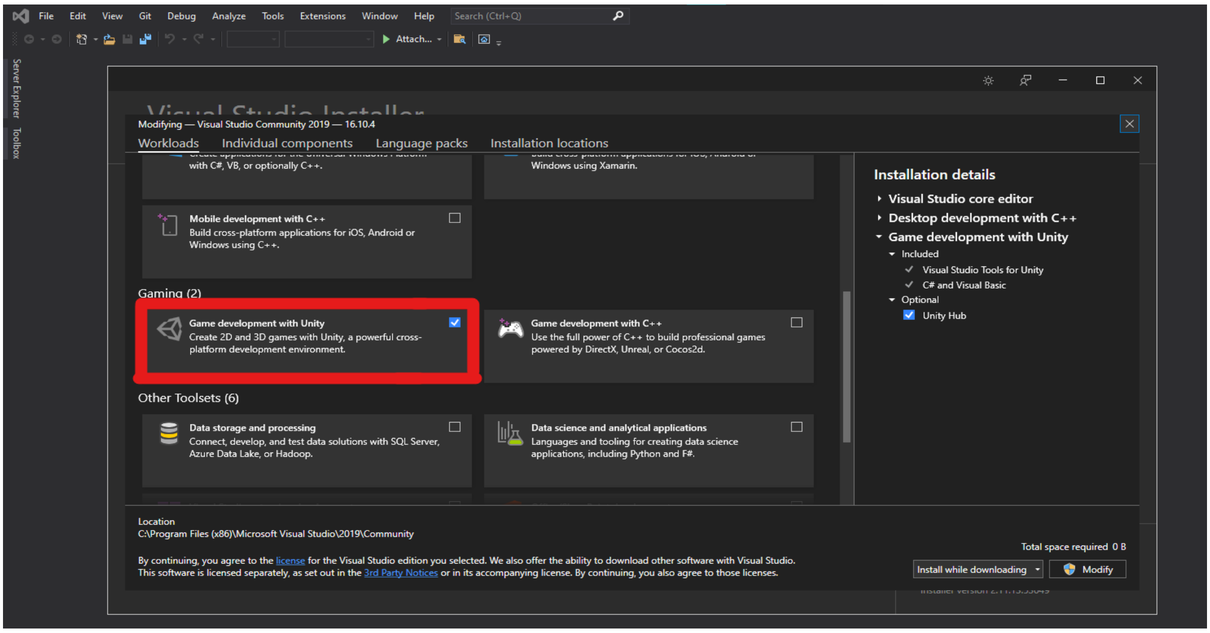
Three-way diff command line

Merge arguments

No supported VCS diff tools were found. Please set up a custom tool or install one of the following tools:

Figure 5.9: Unity3D preference menu

3. In order to get Unity IntelliSense in Visual Studio 2019, go to Tools > Get Tools and Features > Under workload find and install Game Development with Unity.


Modifying — Visual Studio Community 2019 — 16.10.4

with C#, VB, or optionally C++.

Windows using Xamarin.

□ Mobile development with C++
Build cross-platform applications for iOS, Android or Windows using C++.

Gaming (2)

☑ Game development with Unity
Create 2D and 3D games with Unity, a powerful cross-platform development environment.

□ Game development with C++
Use the full power of C++ to build professional games powered by DirectX, Unreal, or Cocos2d.

Other Toolsets (6)

□ Data storage and processing
Connect, develop, and test data solutions with SQL Server, Azure Data Lake, or Hadoop.

□ Data science and analytical applications
Languages and tooling for creating data science applications, including Python and F#.

Installation details
- Visual Studio core editor
- Desktop development with C++
- Game development with Unity
  - Included
    - ✓ Visual Studio Tools for Unity
    - ✓ C# and Visual Basic
  - Optional
    - ☑ Unity Hub

Location
C:\Program Files (x86)\Microsoft Visual Studio\2019\Community

By continuing, you agree to the license for the Visual Studio edition you selected. We also offer the ability to download other software with Visual Studio. This software is licensed separately, as set out in the 3rd Party Notices or in its accompanying license. By continuing, you also agree to those licenses.

Total space required 0 B

Figure 5.10: Microsoft Visual Studio tools

Setting up PlayFab

1. Sign up for an Azure PlayFab account.

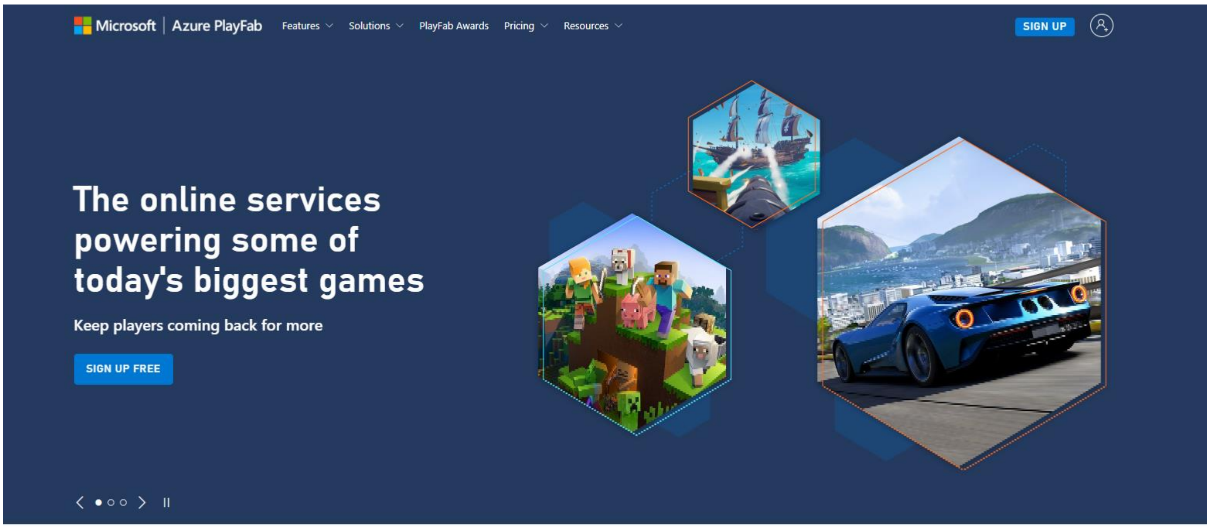
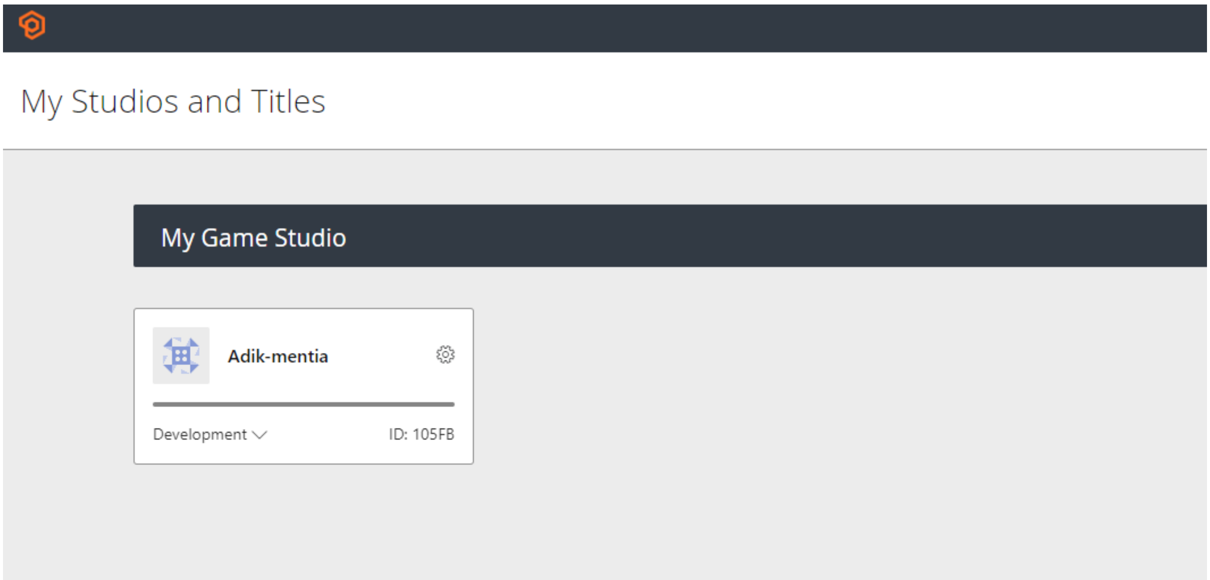

Microsoft | Azure PlayFab
Features
Solutions
PlayFab Awards
Pricing
Resources
SIGN UP
The online services powering some of today's biggest games
Keep players coming back for more
SIGN UP FREE

Figure 5.11: PlayFab login

2. Create a game studio.



My Studios and Titles

My Game Studio

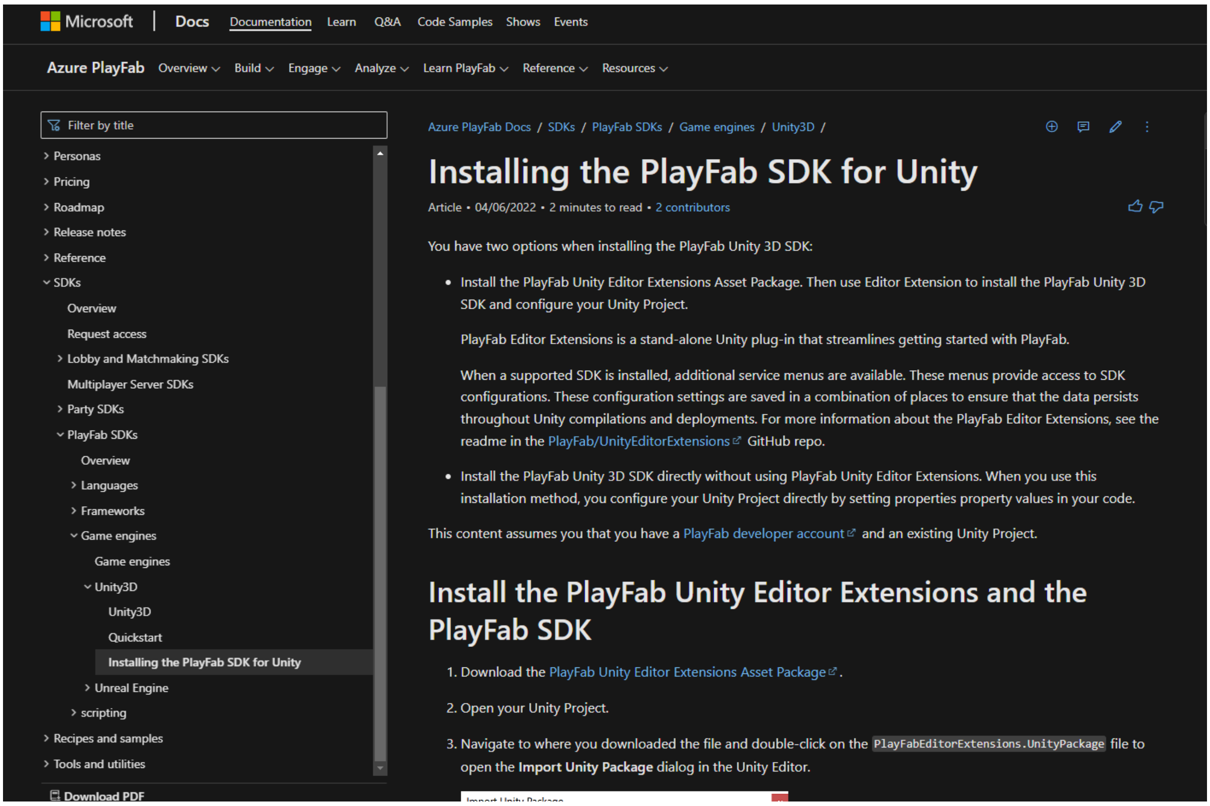
Adik-mentia

Development

ID: 105FB

Figure 5.12: PlayFab game studio menu

3. Download PlayFab Unity Editor Extension Asset Package from Microsoft Azure PlayFab documentation.



Installing the PlayFab SDK for Unity

Article • 04/06/2022 • 2 minutes to read • 2 contributors

You have two options when installing the PlayFab Unity 3D SDK:

- Install the PlayFab Unity Editor Extensions Asset Package. Then use Editor Extension to install the PlayFab Unity 3D SDK and configure your Unity Project.

  PlayFab Editor Extensions is a stand-alone Unity plug-in that streamlines getting started with PlayFab.

  When a supported SDK is installed, additional service menus are available. These menus provide access to SDK configurations. These configuration settings are saved in a combination of places to ensure that the data persists throughout Unity compilations and deployments. For more information about the PlayFab Editor Extensions, see the readme in the PlayFab/UnityEditorExtensions GitHub repo.

- Install the PlayFab Unity 3D SDK directly without using PlayFab Unity Editor Extensions. When you use this installation method, you configure your Unity Project directly by setting properties property values in your code.

This content assumes you that you have a PlayFab developer account and an existing Unity Project.

Install the PlayFab Unity Editor Extensions and the PlayFab SDK

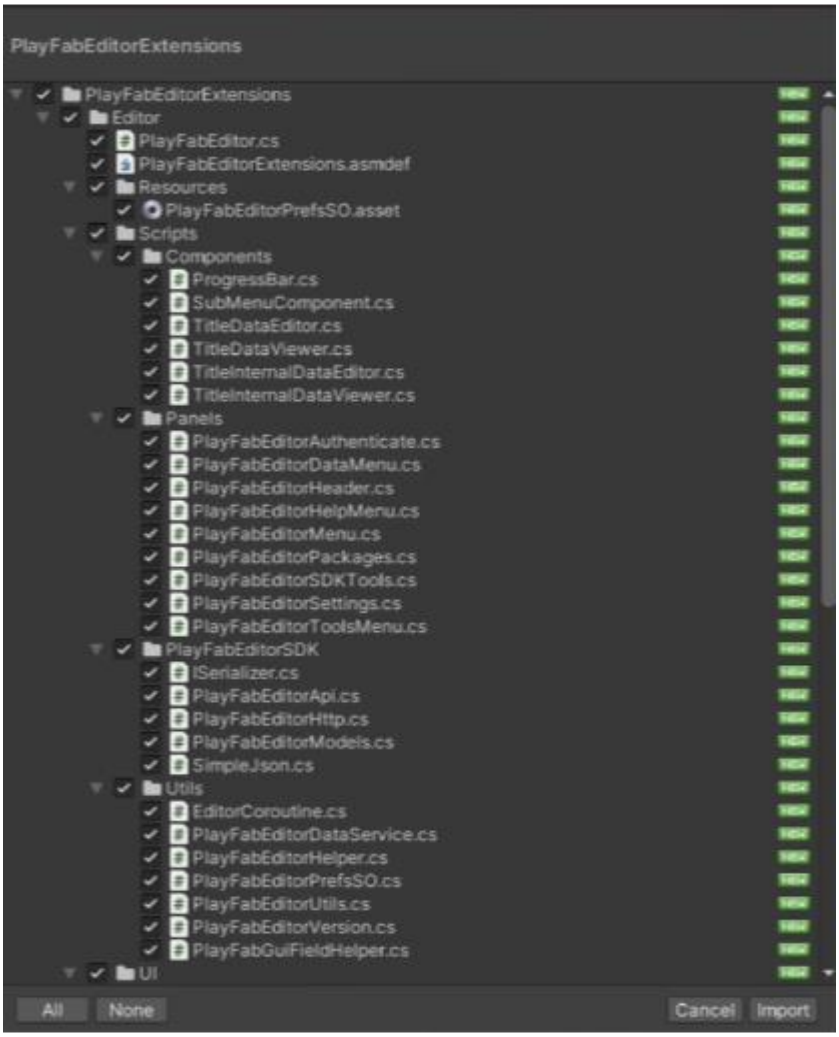
1. Download the PlayFab Unity Editor Extensions Asset Package.

2. Open your Unity Project.

3. Navigate to where you downloaded the file and double-click on the `PlayFabEditorExtensions.UnityPackage` file to open the **Import Unity Package** dialog in the Unity Editor.

Figure 5.13: PlayFab SDK forum

4. In Unity, drag and import the downloaded PlayFab package into project directory

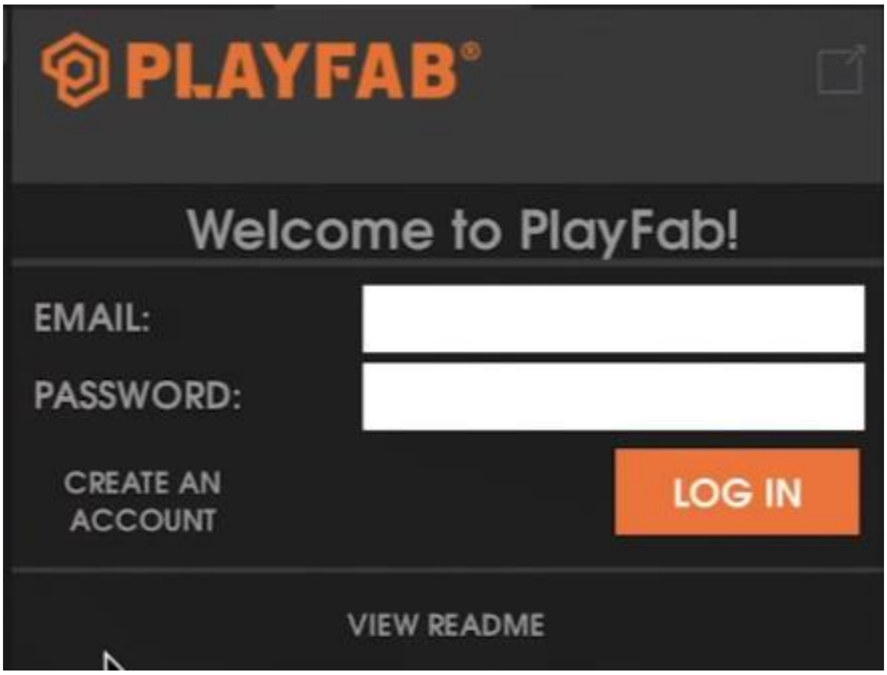


PlayFabEditorExtensions

```
▼ ✓ PlayFabEditorExtensions
  ▼ ✓ Editor
      ✓ PlayFabEditor.cs
      ✓ PlayFabEditorExtensions.asmdef
    ▼ ✓ Resources
        ✓ PlayFabEditorPrefsSO.asset
    ▼ ✓ Scripts
      ▼ ✓ Components
          ✓ ProgressBar.cs
          ✓ SubMenuComponent.cs
          ✓ TitleDataEditor.cs
          ✓ TitleDataViewer.cs
          ✓ TitleInternalDataEditor.cs
          ✓ TitleInternalDataViewer.cs
      ▼ ✓ Panels
          ✓ PlayFabEditorAuthenticate.cs
          ✓ PlayFabEditorDataMenu.cs
          ✓ PlayFabEditorHeader.cs
          ✓ PlayFabEditorHelpMenu.cs
          ✓ PlayFabEditorMenu.cs
          ✓ PlayFabEditorPackages.cs
          ✓ PlayFabEditorSDKTools.cs
          ✓ PlayFabEditorSettings.cs
          ✓ PlayFabEditorToolsMenu.cs
      ▼ ✓ PlayFabEditorSDK
          ✓ ISerializer.cs
          ✓ PlayFabEditorApi.cs
          ✓ PlayFabEditorHttp.cs
          ✓ PlayFabEditorModels.cs
          ✓ SimpleJson.cs
      ▼ ✓ Utils
          ✓ EditorCoroutine.cs
          ✓ PlayFabEditorDataService.cs
          ✓ PlayFabEditorHelper.cs
          ✓ PlayFabEditorPrefsSO.cs
          ✓ PlayFabEditorUtils.cs
          ✓ PlayFabEditorVersion.cs
          ✓ PlayFabGuiFieldHelper.cs
    ▼ ✓ UI
```

Figure 5.14: PlayFab SDK packages

5. A login screen will pop up in the inspector. Login using PlayFab account credentials.



PLAYFAB®

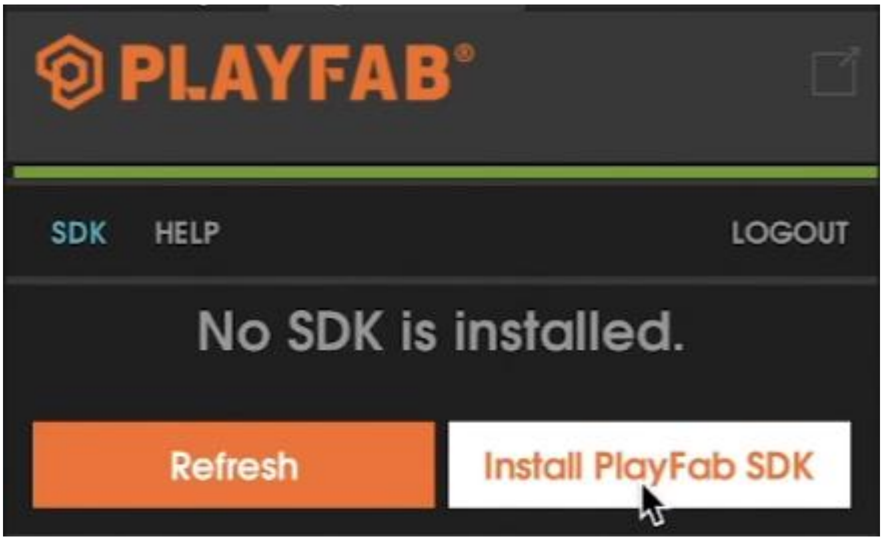
Welcome to PlayFab!

EMAIL:

PASSWORD:

Figure 5.15: PlayFab SDK login

6. Install the PlayFab SDK required.

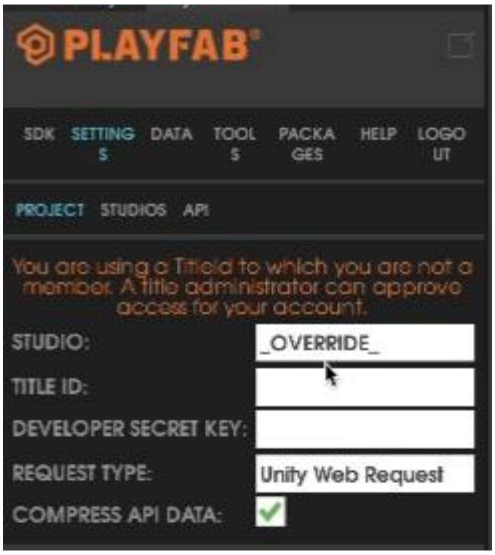


PLAYFAB®

No SDK is installed.

Figure 5.16: PlayFab SDK install

7. After installation, under "Set my title", Choose the Studio and title ID.



You are using a TitleId to which you are not a member. A title administrator can approve access for your account.

STUDIO: _OVERRIDE_

TITLE ID:

DEVELOPER SECRET KEY:

REQUEST TYPE: Unity Web Request

COMPRESS API DATA: ☑

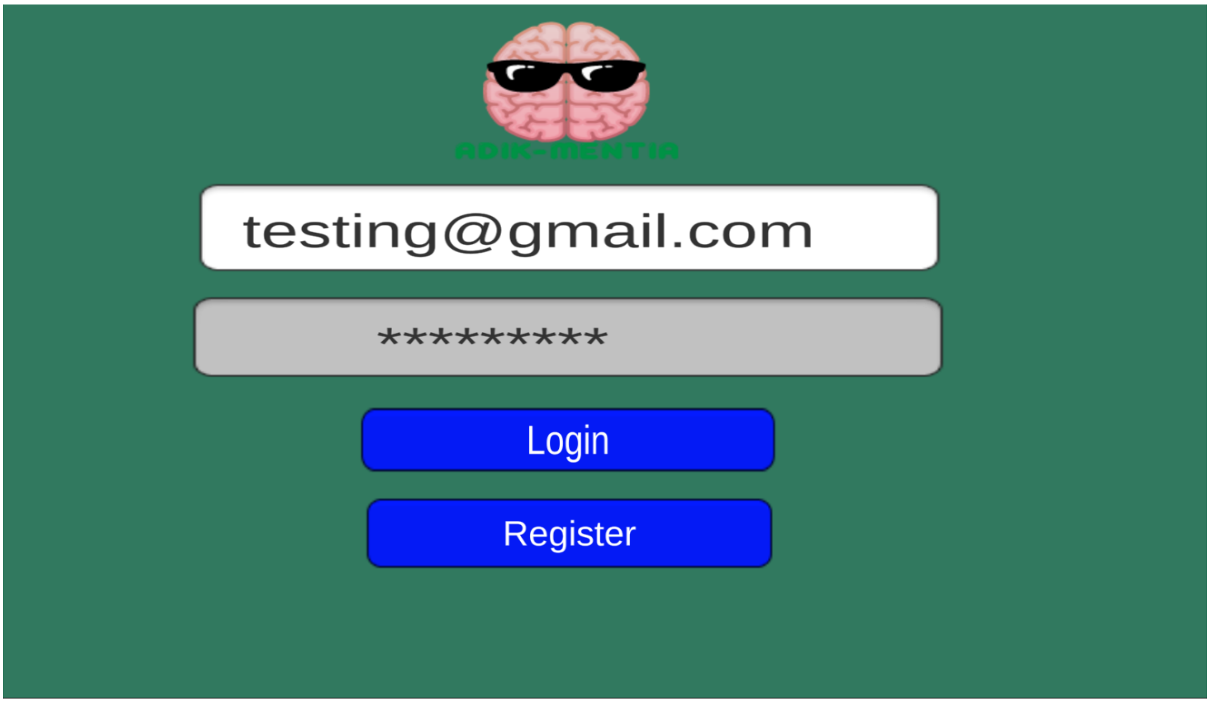
Figure 5.17: PlayFab SDK settings

5.4 System Operation

5.4.1 System Flow Overview

Login/Register

The system will begin with the login screen. User are required to login before starting the game. If the user does not already have an account, they must create one before proceeding.



testing@gmail.com

****

Figure 5.18: Serious game login/Register

After logging in, the user will be presented with several options from the main menu, including Start, Options, Cognitive Score, and Exit.

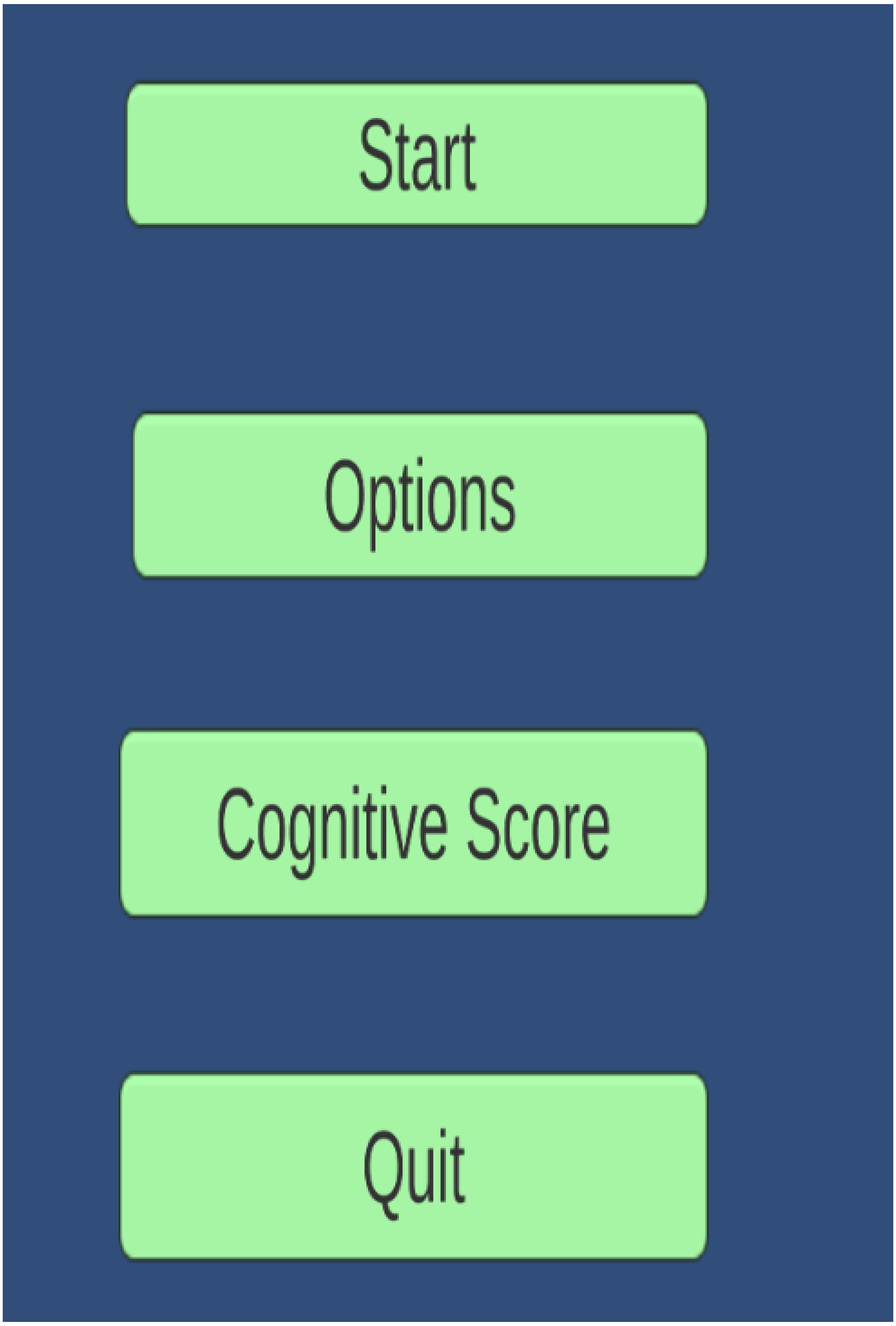
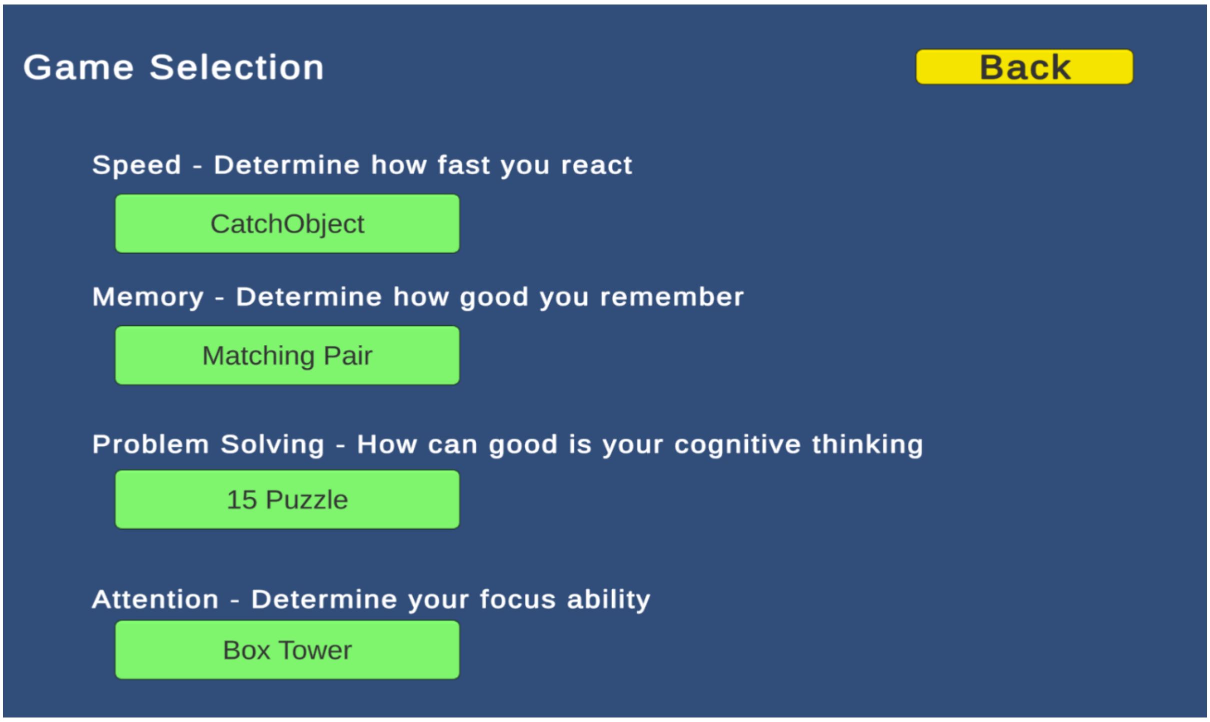


Figure 5.19: Main menu

Serious Game

If the user selects 'Start,' they will be taken to the 'Game Selection' menu. Users can choose games to play from the menu based on game categories such as speed, memory, problem solving, and attention.



Game Selection

Speed - Determine how fast you react

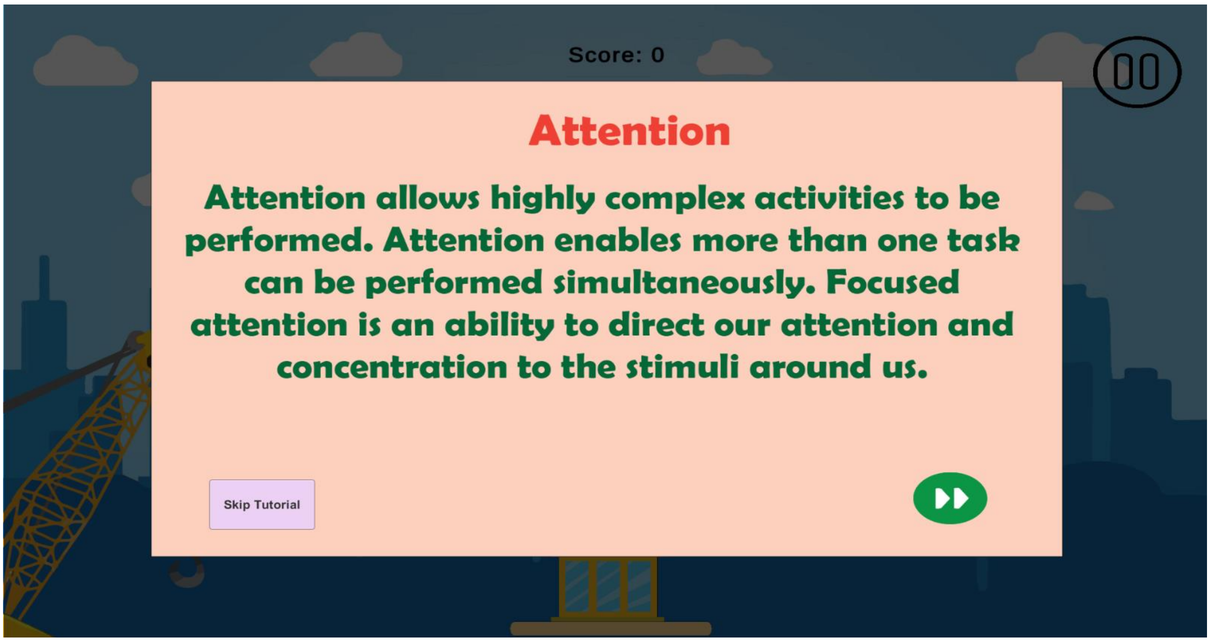
Memory - Determine how good you remember

Problem Solving - How can good is your cognitive thinking

Attention - Determine your focus ability

Figure 5.20: Game Selection

Each game will include a tutorial that will teach users how to play and complete the game.



Attention

Attention allows highly complex activities to be performed. Attention enables more than one task can be performed simultaneously. Focused attention is an ability to direct our attention and concentration to the stimuli around us.

Figure 5.21: Game tutorial

Users can pause the game within the game.

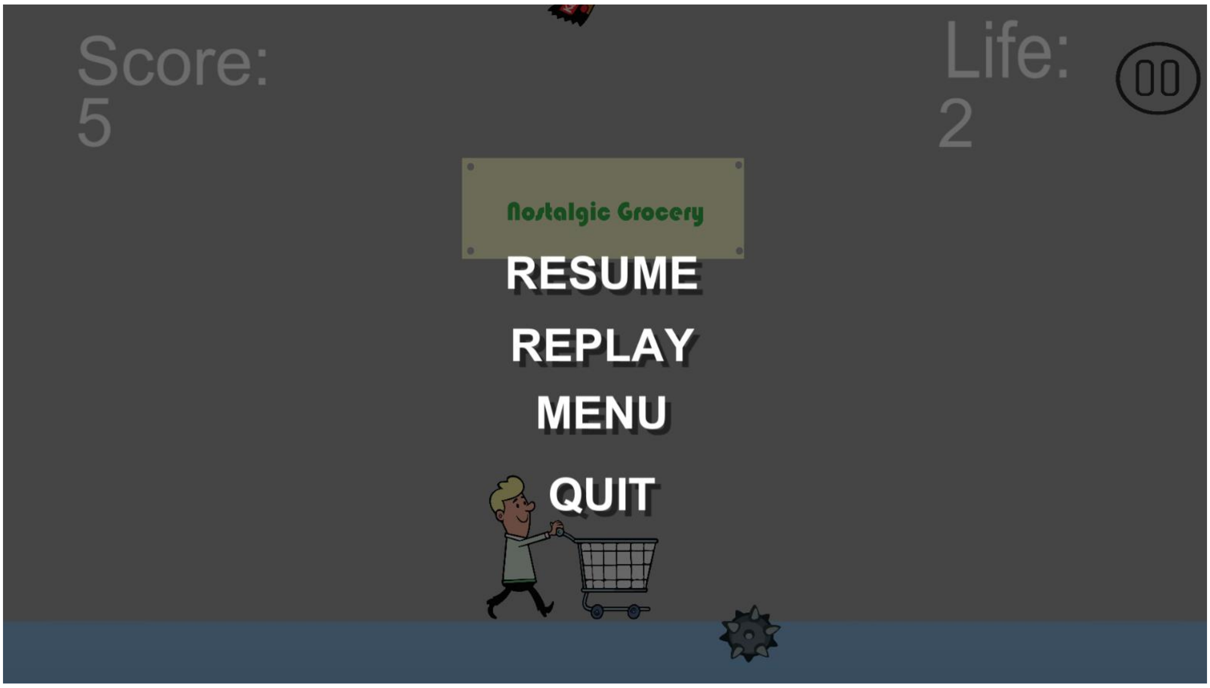


Figure 5.22: Pause game

When the game finishes, a game over scene appears, giving users the option to restart the game, view the community leaderboard, or return to the main menu.

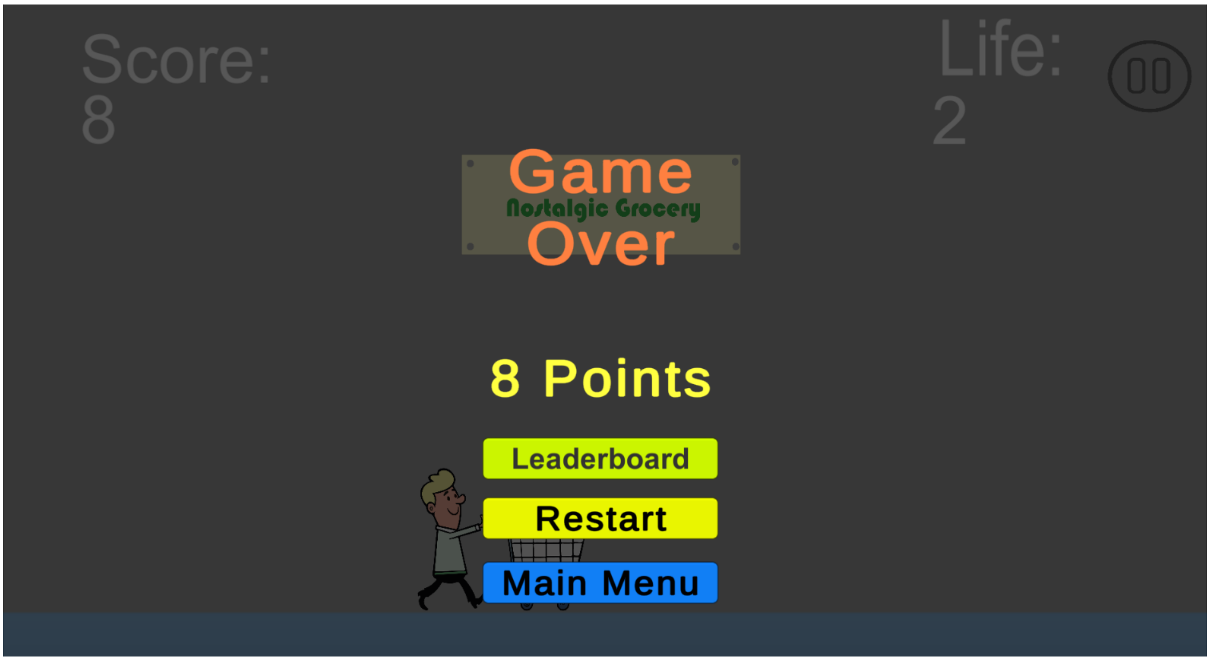
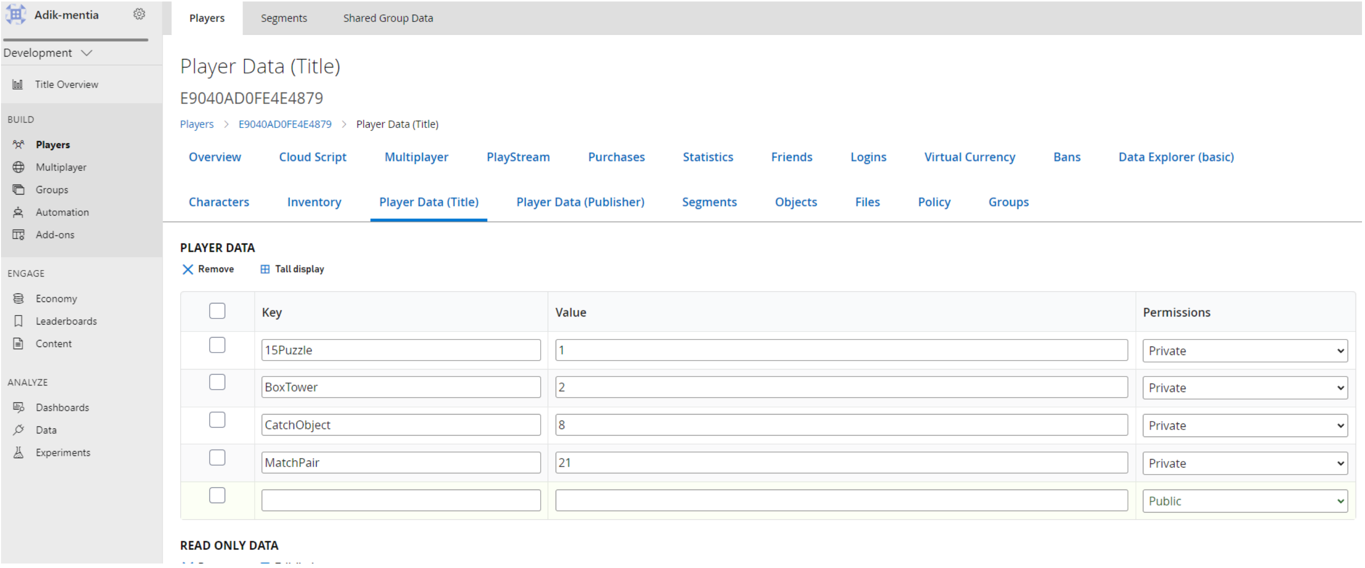


Figure 5.23: Game over

After the game, the cloud will be updated with the player's score. If a player breaks the previous game score record, the leaderboard will be updated.



Player Data (Title)

E9040AD0FE4E4879

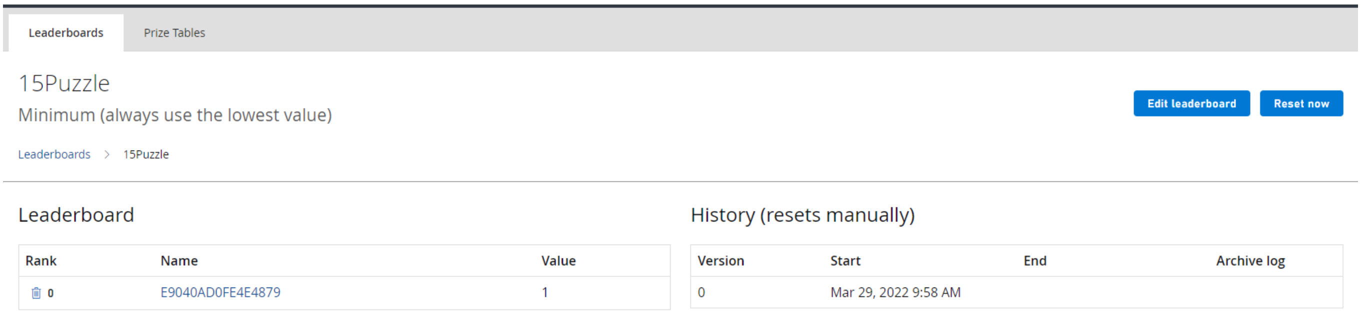
Players > E9040AD0FE4E4879 > Player Data (Title)

PLAYER DATA

□	Key	Value	Permissions
□	15Puzzle	1	Private
□	BoxTower	2	Private
□	CatchObject	8	Private
□	MatchPair	21	Private
□			Public

READ ONLY DATA

Figure 5.24: PlayFab Player data



15Puzzle

Minimum (always use the lowest value)

Leaderboards > 15Puzzle

Leaderboard

Rank	Name	Value
0	E9040AD0FE4E4879	1

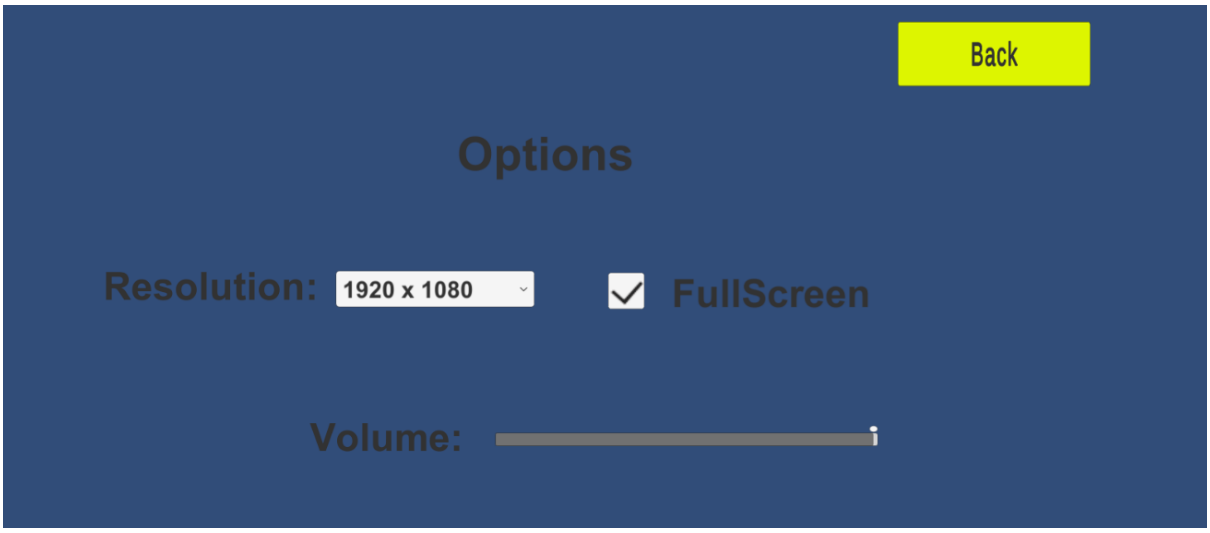
History (resets manually)

Version	Start	End	Archive log
0	Mar 29, 2022 9:58 AM		

Figure 5.25: PlayFab Leaderboard

Options

The user can change the screen resolution, set full screen, or adjust the game volume under Options.



Resolution: 1920 x 1080

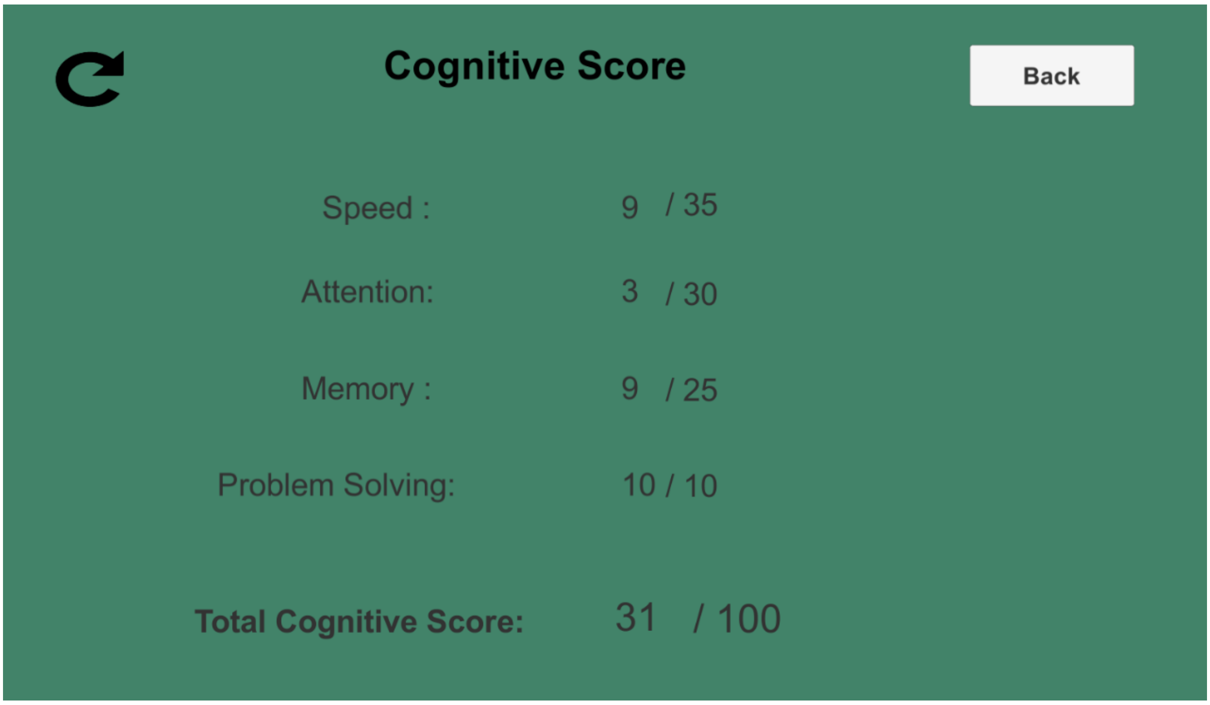
☑ FullScreen

Volume:

Figure 5.26: Options

Cognitive Score

The cognitive score is divided into four categories: speed, attention, memory, and problem solving. Based on the results of each category, an overall cognitive score will be computed. The user can refresh to obtain the most recent cognitive score.



Speed : 9 / 35

Attention: 3 / 30

Memory : 9 / 25

Problem Solving: 10 / 10

Total Cognitive Score: 31 / 100

Figure 5.27: Cognitive score

5.4.2 Game Mechanism

The project includes four different games. "Catch Falling Object," "Box Tower," "Matching Pair," and "15 Puzzle" are the games. The design of game mechanisms ensures that the games can perform and obtain scores correctly.

Catch Falling Objects

The game "Catch Falling Objects" is intended for the Speed category. The game's goal is to allow the player to catch falling objects. Malaysian nostalgic snacks such as Mamee Monster, Rabbit Milk Candy, Kopiko, and others are used as game objects. Bombs are the game objects that players must avoid. At random intervals, game objects spawn and drop. Players must control the character in order to collect snacks while avoiding bombs. A successful snack catch will result in a score of one. The bombs will cause the player to lose; if the player misses three snacks, they will also lose.

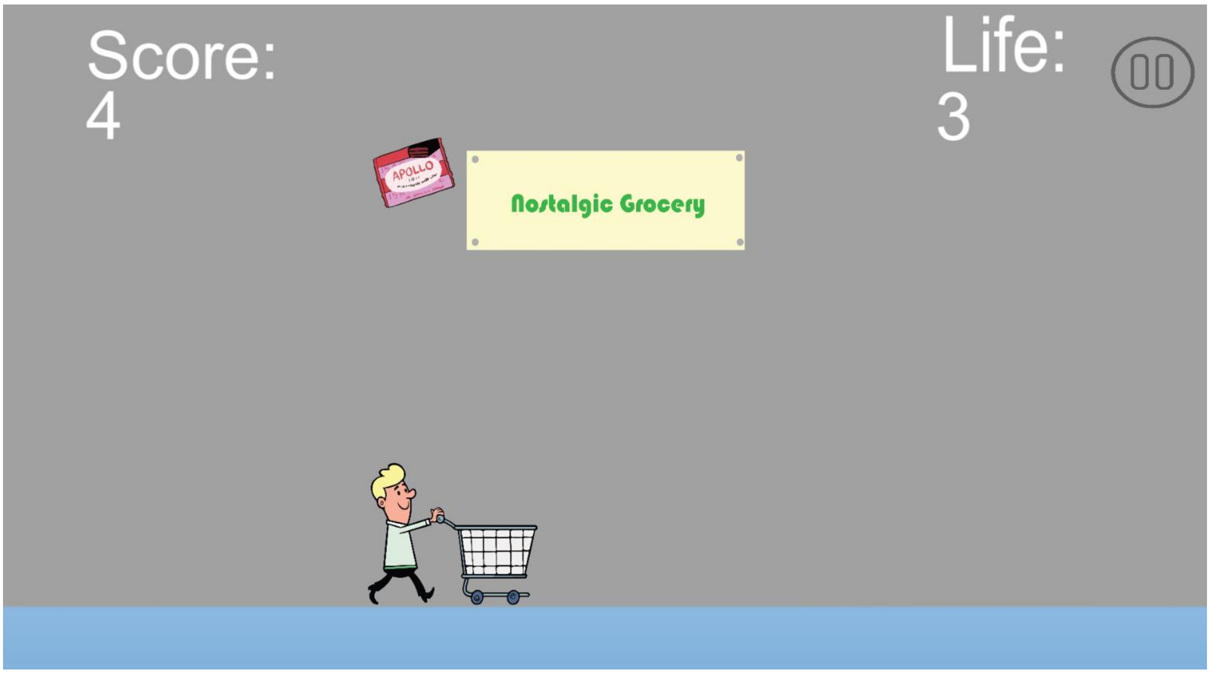


Figure 5.28: Catch falling objects game interface

Matching Pair

The game "Matching Pair" falls under the category of "Memory." The game is made up of ten pairs of similar cards. Each card pair represents Malaysian cuisine, such as Nasi Lemak, Laksa, and Satay. Each time, players have the option of folding open a card. Players must remember the position and image on the card in order to find the other similar card. A maximum of two cards can be folded open at the same time. Every time a new game begins, the card will be randomised. Players must complete the game in 60 seconds, or they will lose.

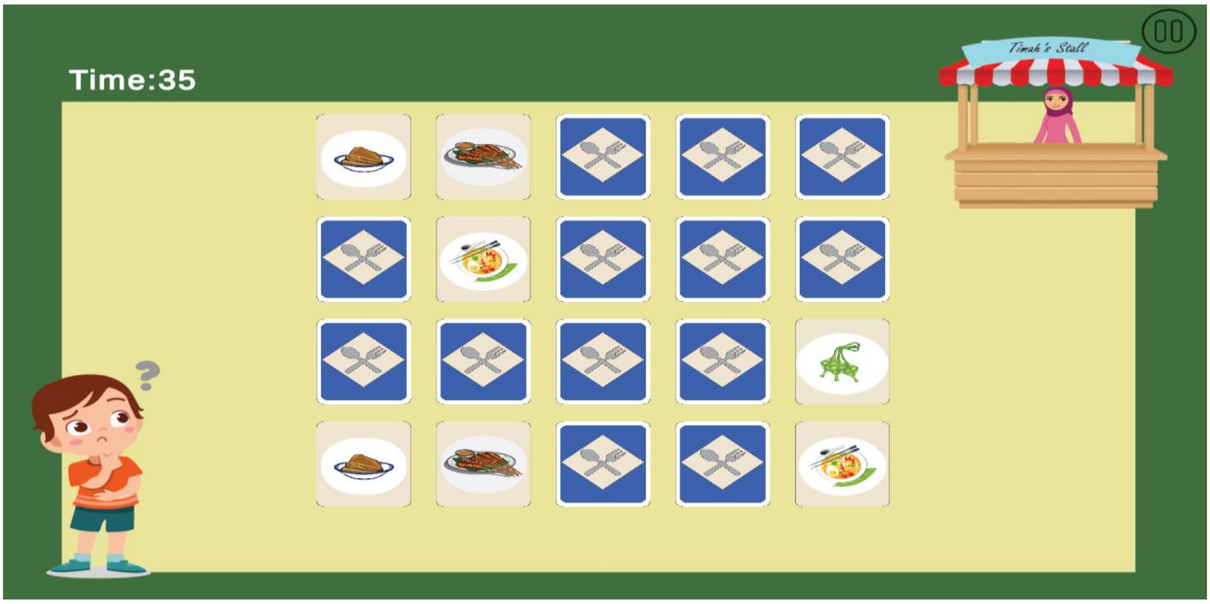


Figure 5.29: Matching pair game interface

Box Tower

The Box Tower is a game that requires players to focus. Boxes spawn at the top of the screen, and players must time them before dropping them on the box stacks. The boxes are stacked on top of each other, and each successful stack awards players one point. The game is over if the box falls or fails to stack.

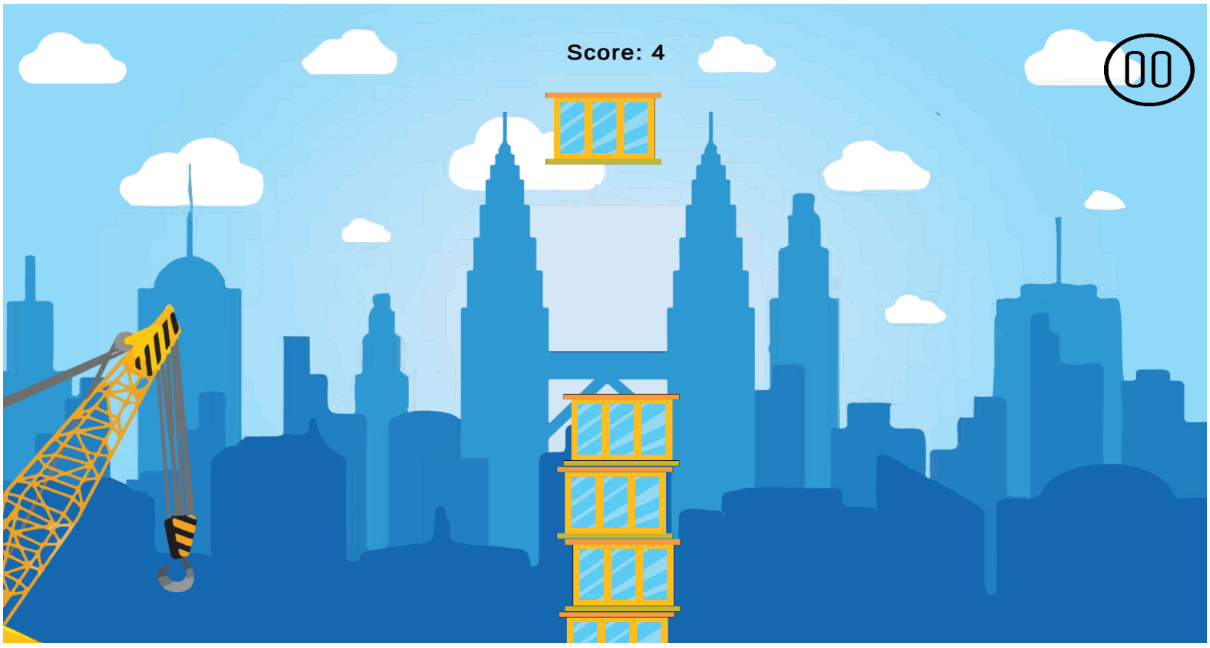


Figure 5.30: Box tower game interface

15Puzzle

The 15Puzzle is a puzzle game in which players must arrange a randomised numbered puzzle. The player has the ability to slide and change a number position at the same time. When the puzzle is solved, the player wins. The amount of time required will be a determining factor in the player's problem-solving ability.

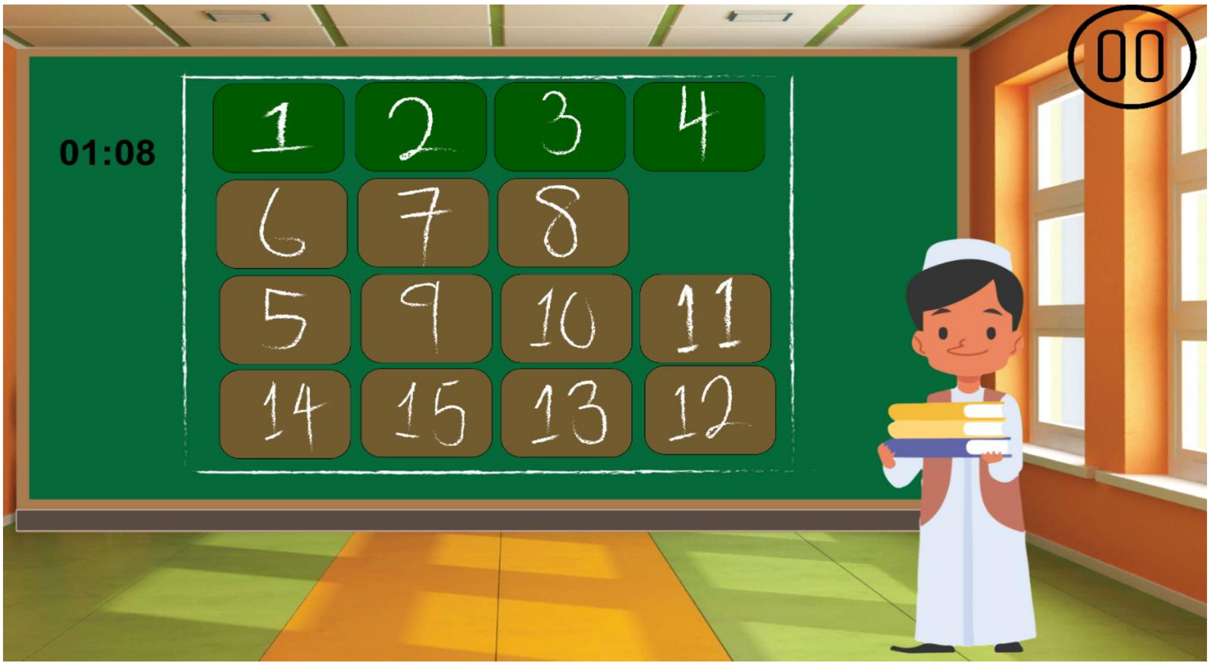
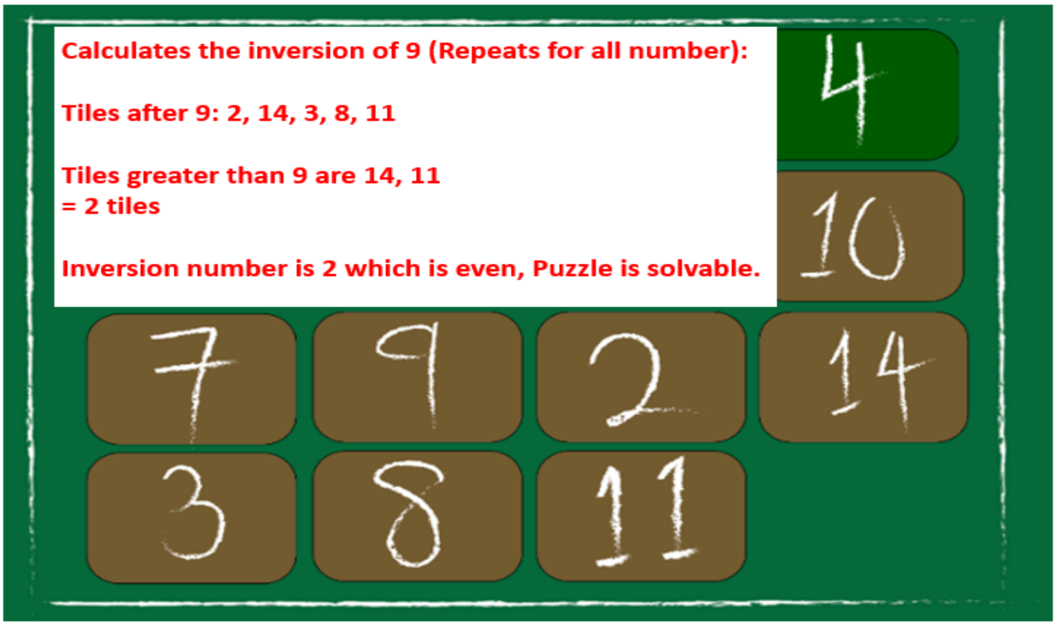


Figure 5.31: 15puzzle game interface

Since 15puzzle is a puzzle game, some sort of algorithm is required to ensure that the puzzle can be solved. The 15 puzzle tiles will be organised into an array that will be shuffled. Inversion will be used in the puzzle tile shuffle system. Inversion is an algorithm that calculates the number of tiles that are later and larger than the number of tiles that are targeted. Inversion number is applied to every tile in the puzzle. If the inversion number is even, the puzzle is solvable; if the inversion number is odd, the puzzle is unsolvable.



Calculates the inversion of 9 (Repeats for all number):

Tiles after 9: 2, 14, 3, 8, 11

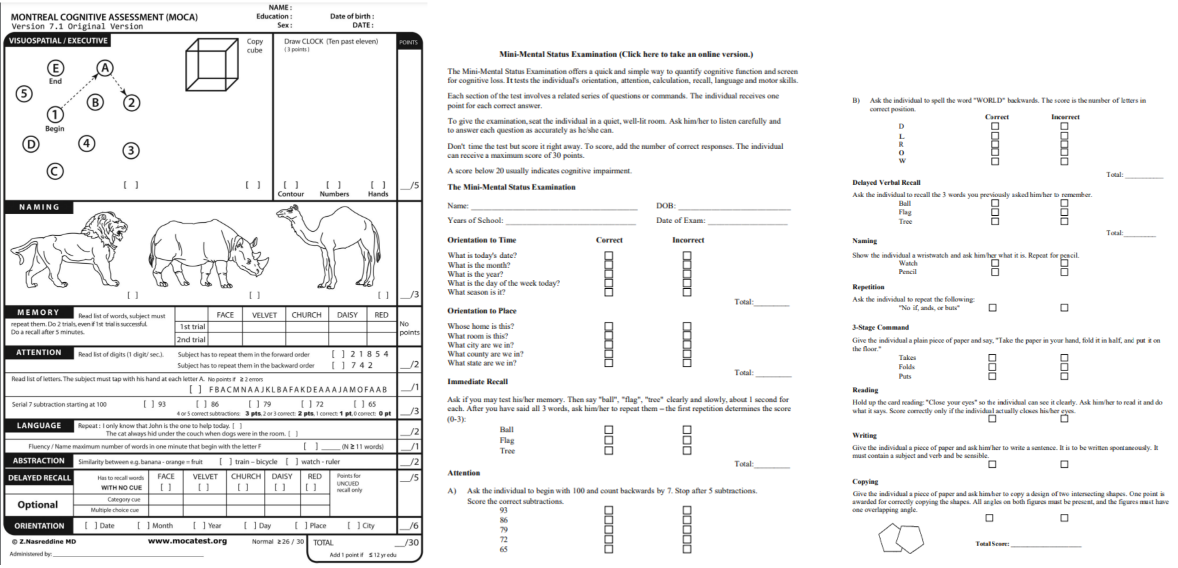
Tiles greater than 9 are 14, 11
= 2 tiles

Inversion number is 2 which is even, Puzzle is solvable.

Figure 5.32: Inversion of a number

Cognitive Score

The Serious game for dementia prevention is centred on the cognitive score. The cognitive score is based on four cognitive categories: speed, attention, memory, and problem solving. Based on the Montreal Cognitive Assessment (MoCA) and the Mini-Mental State Examination (MMSE), the weightage of each category in the cognitive score will be determined. Each MMSE and MoCA question will be reviewed and referenced as part of the game scoring matrix. Each test has a total score of 35 for MMSE and 30 for MoCA.



MONTREAL COGNITIVE ASSESSMENT (MOCA)
Version 7.1 Original Version

NAME :
Education :　Date of birth :
Sex :　DATE :

POINTS

VISUOSPATIAL / EXECUTIVE　Copy cube　Draw CLOCK (Ten past eleven) (3 points)
[ ]　[ ]　[ ] Contour　[ ] Numbers　[ ] Hands　__/5

E
End
A
5
B
2
1
Begin
D
4
3
C

NAMING　[ ]　[ ]　[ ]　__/3

MEMORY		FACE	VELVET	CHURCH	DAISY	RED	
Read list of words, subject must repeat them. Do 2 trials, even if 1st trial is successful. Do a recall after 5 minutes.	1st trial						No points
	2nd trial						

ATTENTION　Read list of digits (1 digit/ sec.).　Subject has to repeat them in the forward order　[ ] 2 1 8 5 4
Subject has to repeat them in the backward order　[ ] 7 4 2　__/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors
[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B　__/1

Serial 7 subtraction starting at 100　[ ] 93　[ ] 86　[ ] 79　[ ] 72　[ ] 65
4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt**　__/3

LANGUAGE　Repeat : I only know that John is the one to help today. [ ]
The cat always hid under the couch when dogs were in the room. [ ]　__/2

Fluency / Name maximum number of words in one minute that begin with the letter F　[ ] ____ (N ≥ 11 words)　__/1

ABSTRACTION　Similarity between e.g. banana - orange = fruit　[ ] train – bicycle　[ ] watch - ruler　__/2

DELAYED RECALL	Has to recall words WITH NO CUE	FACE [ ]	VELVET [ ]	CHURCH [ ]	DAISY [ ]	RED [ ]	Points for UNCUED recall only	__/5
Optional	Category cue							
	Multiple choice cue							

ORIENTATION　[ ] Date　[ ] Month　[ ] Year　[ ] Day　[ ] Place　[ ] City　__/6

© Z.Nasreddine MD　www.mocatest.org　Normal ≥ 26 / 30　TOTAL __/30
Add 1 point if ≤ 12 yr edu
Administered by: ________________

Mini-Mental Status Examination (Click here to take an online version.)

The Mini-Mental Status Examination offers a quick and simple way to quantify cognitive function and screen for cognitive loss. It tests the individual's orientation, attention, calculation, recall, language and motor skills.

Each section of the test involves a related series of questions or commands. The individual receives one point for each correct answer.

To give the examination, seat the individual in a quiet, well-lit room. Ask him/her to listen carefully and to answer each question as accurately as he/she can.

Don't time the test but score it right away. To score, add the number of correct responses. The individual can receive a maximum score of 30 points.

A score below 20 usually indicates cognitive impairment.

The Mini-Mental Status Examination

Name: ____________________　DOB: ____________________
Years of School: ____________________　Date of Exam: ____________________

Orientation to Time	**Correct**	**Incorrect**
What is today's date?	□	□
What is the month?	□	□
What is the year?	□	□
What is the day of the week today?	□	□
What season is it?	□	□

Total:________

Orientation to Place		
Whose home is this?	□	□
What room is this?	□	□
What city are we in?	□	□
What county are we in?	□	□
What state are we in?	□	□

Total: ________

Immediate Recall

Ask if you may test his/her memory. Then say "ball", "flag", "tree" clearly and slowly, about 1 second for each. After you have said all 3 words, ask him/her to repeat them – the first repetition determines the score (0-3):

Ball	□	□
Flag	□	□
Tree	□	□

Total:________

Attention

A) Ask the individual to begin with 100 and count backwards by 7. Stop after 5 subtractions. Score the correct subtractions.

93	□	□
86	□	□
79	□	□
72	□	□
65	□	□

B) Ask the individual to spell the word "WORLD" backwards. The score is the number of letters in correct position.

	Correct	Incorrect
D	□	□
L	□	□
R	□	□
O	□	□
W	□	□

Total: ________

Delayed Verbal Recall

Ask the individual to recall the 3 words you previously asked him/her to remember.

Ball	□	□
Flag	□	□
Tree	□	□

Total:________

Naming

Show the individual a wristwatch and ask him/her what it is. Repeat for pencil.

Watch	□	□
Pencil	□	□

Repetition

Ask the individual to repeat the following:

"No if, ands, or buts"	□	□

3-Stage Command

Give the individual a plain piece of paper and say, "Take the paper in your hand, fold it in half, and put it on the floor."

Takes	□	□
Folds	□	□
Puts	□	□

Reading

Hold up the card reading: "Close your eyes" so the individual can see it clearly. Ask him/her to read it and do what it says. Score correctly only if the individual actually closes his/her eyes.
□　□

Writing

Give the individual a piece of paper and ask him/her to write a sentence. It is to be written spontaneously. It must contain a subject and verb and be sensible.
□　□

Copying

Give the individual a piece of paper and ask him/her to copy a design of two intersecting shapes. One point is awarded for correctly copying the shapes. All angles on both figures must be present, and the figures must have one overlapping angle.
□　□

Total Score: ____________

Figure 5.33: Sample Mini-Mental State Examination (MMSE)/ Montreal Cognitive Assessment (MoCA)

Weightage of each category based on MMSE and MoCA:

Categories **Test/Type**	**Speed**	**Memory**	**Attention**	**Problem Solving**
MMSE	Orientation Naming Repetition	Immediate Recall Delayed Verbal Recall	Attention Reading	3 Stage - Command Writing Copying
	13	6	11	5
MoCA	Naming Abstraction Orientation	Delayed Recall Language	Attention Language	Visuospatial/ Executive
	11	6	8	5
Total	25	12	19	10

Table 5.6: Categories weightage

According to the score distributed for each category, the order of score weightage will be Speed > Attention > Memory > Problem Solving.

With an overall cognitive score of 100, the score for each category can be divided into:

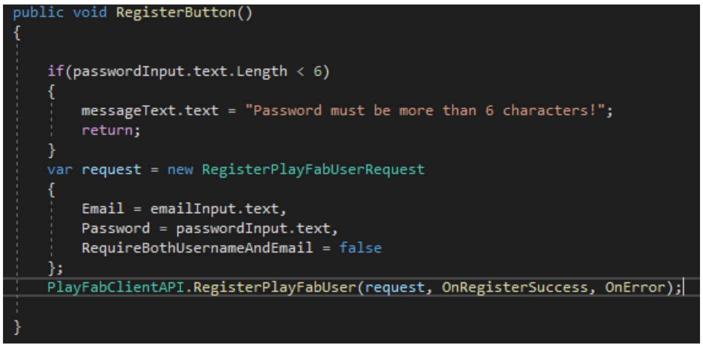
Categories	**Speed**	**Memory**	**Attention**	**Problem Solving**	**Overall**
Weightage	35	30	20	15	100

Table 5.7: Categories weightage (%)

5.4.3 Code Inspection

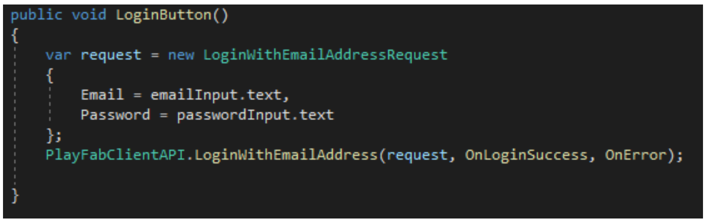
Game scripts are used to interact with the PlayFab API, control game objects, perform calculations, and manage game flows. In the serious game, various scripts are created for various purposes.

Login



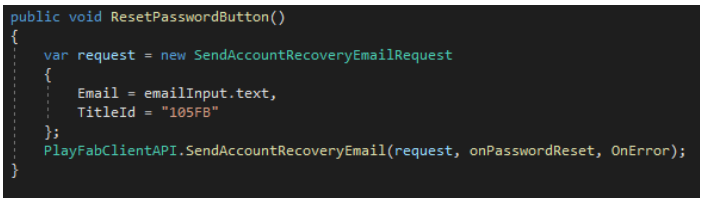
```
public void RegisterButton()
{

    if(passwordInput.text.Length < 6)
    {
        messageText.text = "Password must be more than 6 characters!";
        return;
    }
    var request = new RegisterPlayFabUserRequest
    {
        Email = emailInput.text,
        Password = passwordInput.text,
        RequireBothUsernameAndEmail = false
    };
    PlayFabClientAPI.RegisterPlayFabUser(request, OnRegisterSuccess, OnError);

}
```

Figure 5.34: Script for register



```
public void LoginButton()
{
    var request = new LoginWithEmailAddressRequest
    {
        Email = emailInput.text,
        Password = passwordInput.text
    };
    PlayFabClientAPI.LoginWithEmailAddress(request, OnLoginSuccess, OnError);

}
```

Figure 5.35: Script for login

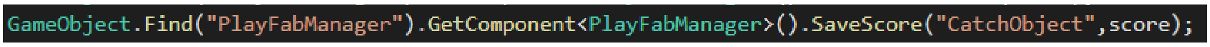


```
public void ResetPasswordButton()
{
    var request = new SendAccountRecoveryEmailRequest
    {
        Email = emailInput.text,
        TitleId = "105FB"
    };
    PlayFabClientAPI.SendAccountRecoveryEmail(request, onPasswordReset, OnError);
}
```

Figure 5.36: Script for reset password

The above code sent player information to PlayFab through API method call using request object for registration, login and reset password.

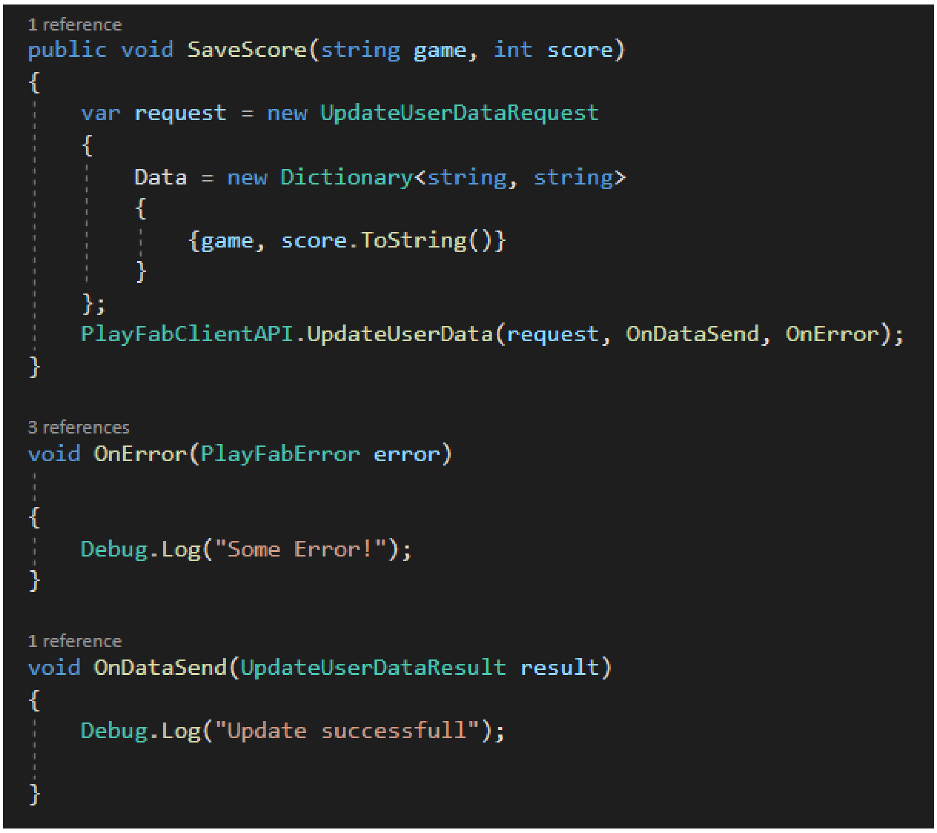
Player Data



```
GameObject.Find("PlayFabManager").GetComponent<PlayFabManager>().SaveScore("CatchObject",score);
```

Figure 5.37: Script for calling send player data

The above code calls Save Score function to save player data into PlayFab by providing game and the score as parameters.

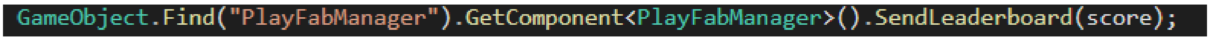


```
1 reference
public void SaveScore(string game, int score)
{
    var request = new UpdateUserDataRequest
    {
        Data = new Dictionary<string, string>
        {
            {game, score.ToString()}
        }
    };
    PlayFabClientAPI.UpdateUserData(request, OnDataSend, OnError);
}

3 references
void OnError(PlayFabError error)

{
    Debug.Log("Some Error!");
}

1 reference
void OnDataSend(UpdateUserDataResult result)
{
    Debug.Log("Update successfull");

}
```

Figure 5.38: Script for send player data

The Save Score receive the parameter parse them into key-value pair as request and send to PlayFab using UpdateUserData API method.

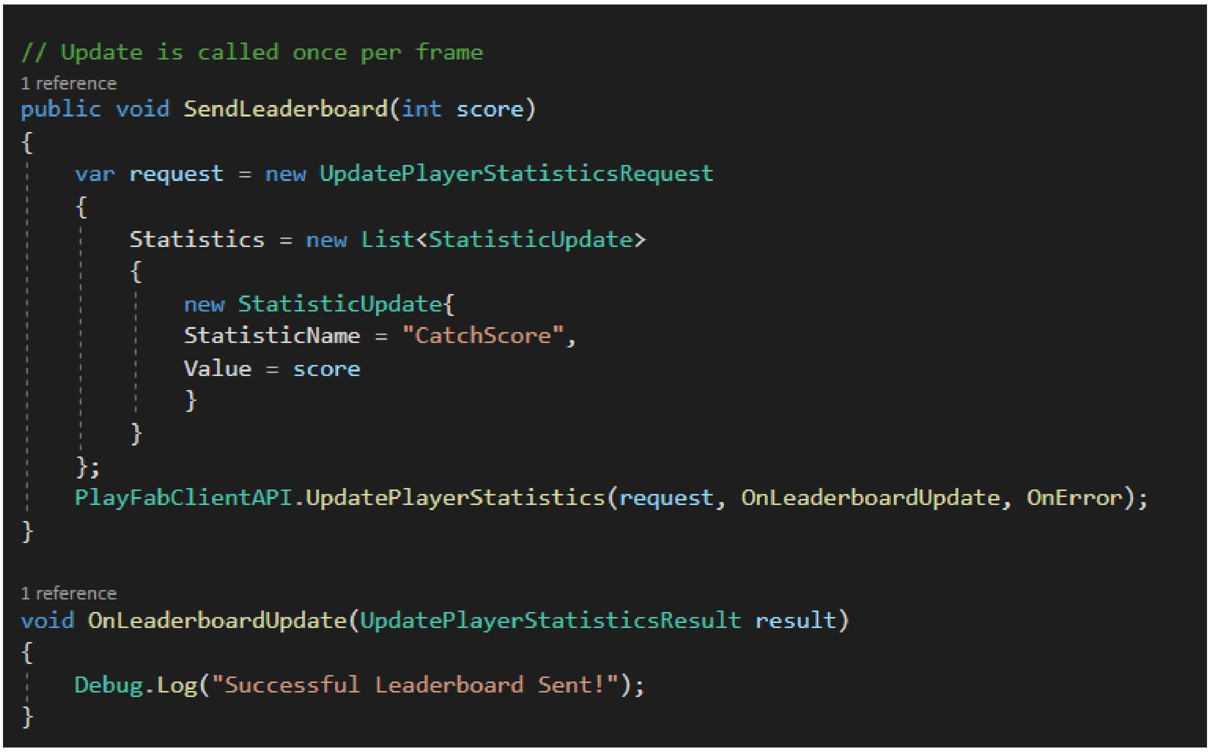
Leaderboard



```
GameObject.Find("PlayFabManager").GetComponent<PlayFabManager>().SendLeaderboard(score);
```

Figure 5.39: Script for calling send leaderboard

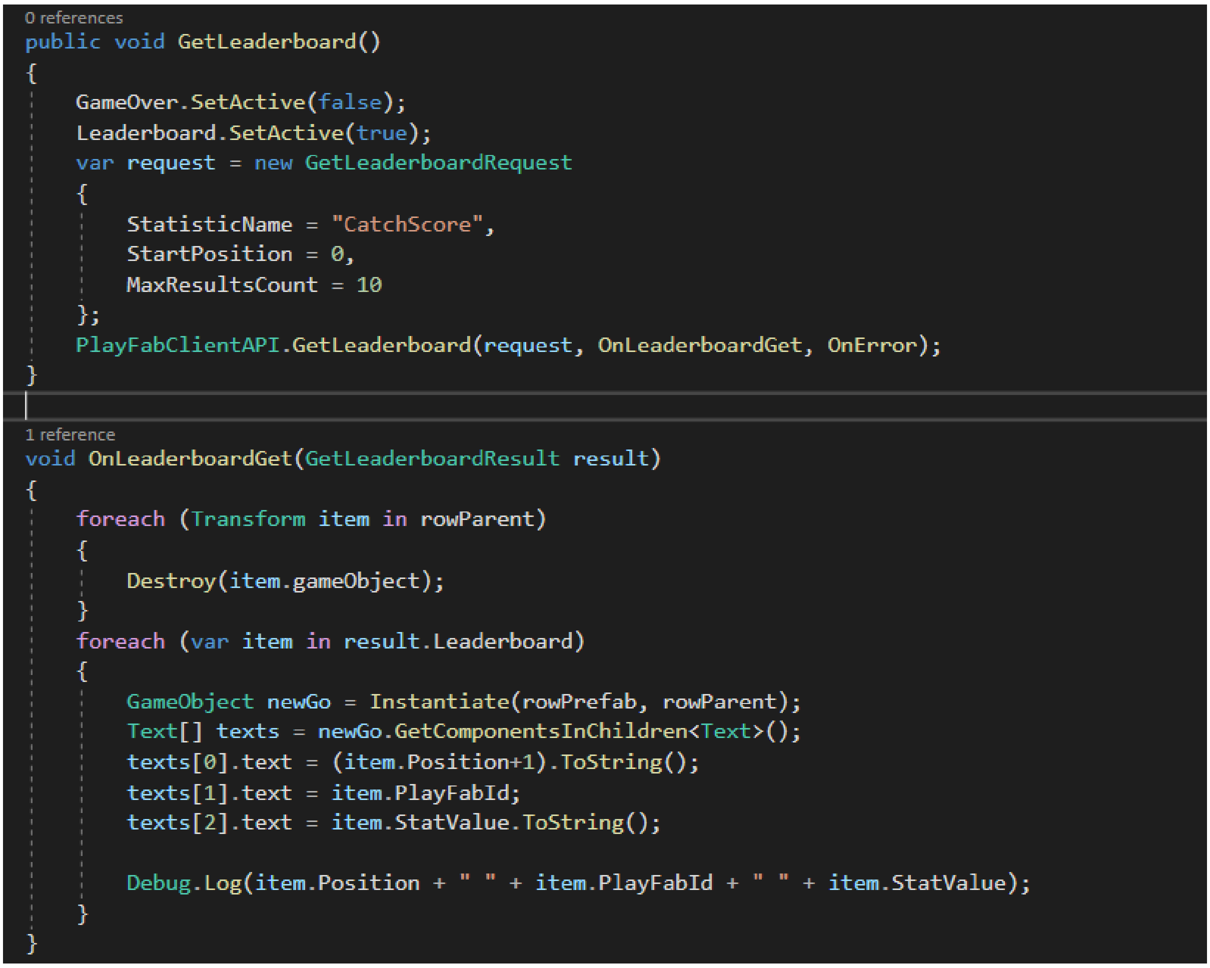
The above code calls SendLeaderbord and provide user score as the score as parameter.



```
// Update is called once per frame
1 reference
public void SendLeaderboard(int score)
{
    var request = new UpdatePlayerStatisticsRequest
    {
        Statistics = new List<StatisticUpdate>
        {
            new StatisticUpdate{
            StatisticName = "CatchScore",
            Value = score
            }
        }
    };
    PlayFabClientAPI.UpdatePlayerStatistics(request, OnLeaderboardUpdate, OnError);
}

1 reference
void OnLeaderboardUpdate(UpdatePlayerStatisticsResult result)
{
    Debug.Log("Successful Leaderboard Sent!");
}
```

Figure 5.40: Script for send leaderboard

The function SendLeaderboard takes score as parameter. The function parses the leaderboard game and score as request. The data are then sent to PlayFab via UpdatePlayerStatistics API method.

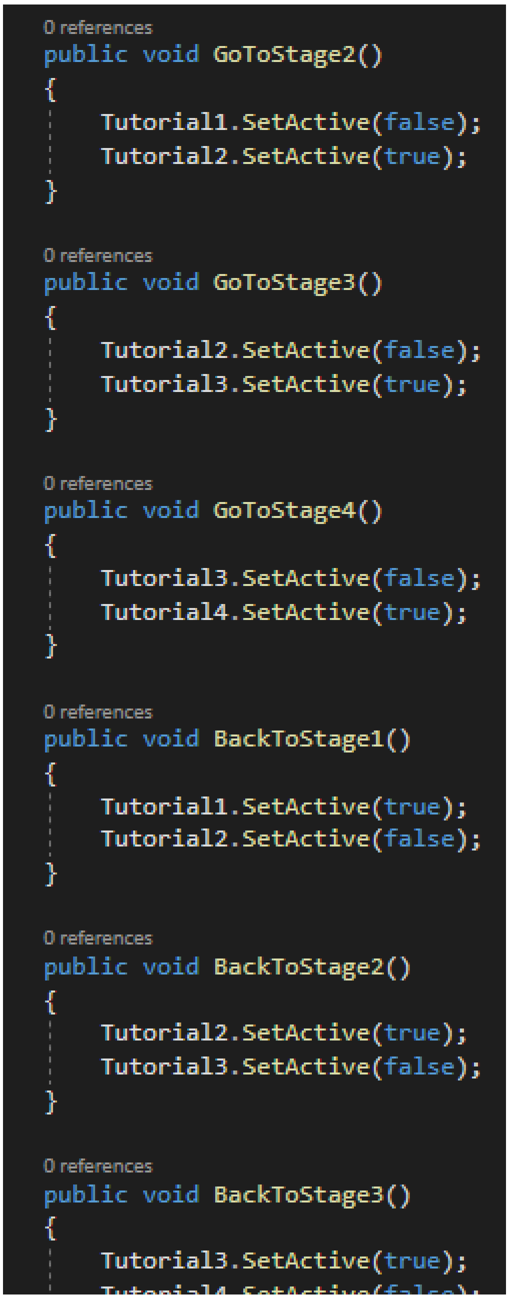


```
0 references
public void GetLeaderboard()
{
    GameOver.SetActive(false);
    Leaderboard.SetActive(true);
    var request = new GetLeaderboardRequest
    {
        StatisticName = "CatchScore",
        StartPosition = 0,
        MaxResultsCount = 10
    };
    PlayFabClientAPI.GetLeaderboard(request, OnLeaderboardGet, OnError);
}

1 reference
void OnLeaderboardGet(GetLeaderboardResult result)
{
    foreach (Transform item in rowParent)
    {
        Destroy(item.gameObject);
    }
    foreach (var item in result.Leaderboard)
    {
        GameObject newGo = Instantiate(rowPrefab, rowParent);
        Text[] texts = newGo.GetComponentsInChildren<Text>();
        texts[0].text = (item.Position+1).ToString();
        texts[1].text = item.PlayFabId;
        texts[2].text = item.StatValue.ToString();

        Debug.Log(item.Position + " " + item.PlayFabId + " " + item.StatValue);
    }
}
```

Figure 5.41: Script for get leaderboard

The method GetLeaderboard is used to retrieved leaderboard data for display. The function will take in leaderboard name, position and result count as request parameter. The GetLeaderboard API method is called to retrieve the data. If the leaderboard is successfully retrieved, the OnLeaderboardGet function will be called. The function will take in the return result and displayed them in the game. The return result consists of Position, User ID and their score in the leaderboard.

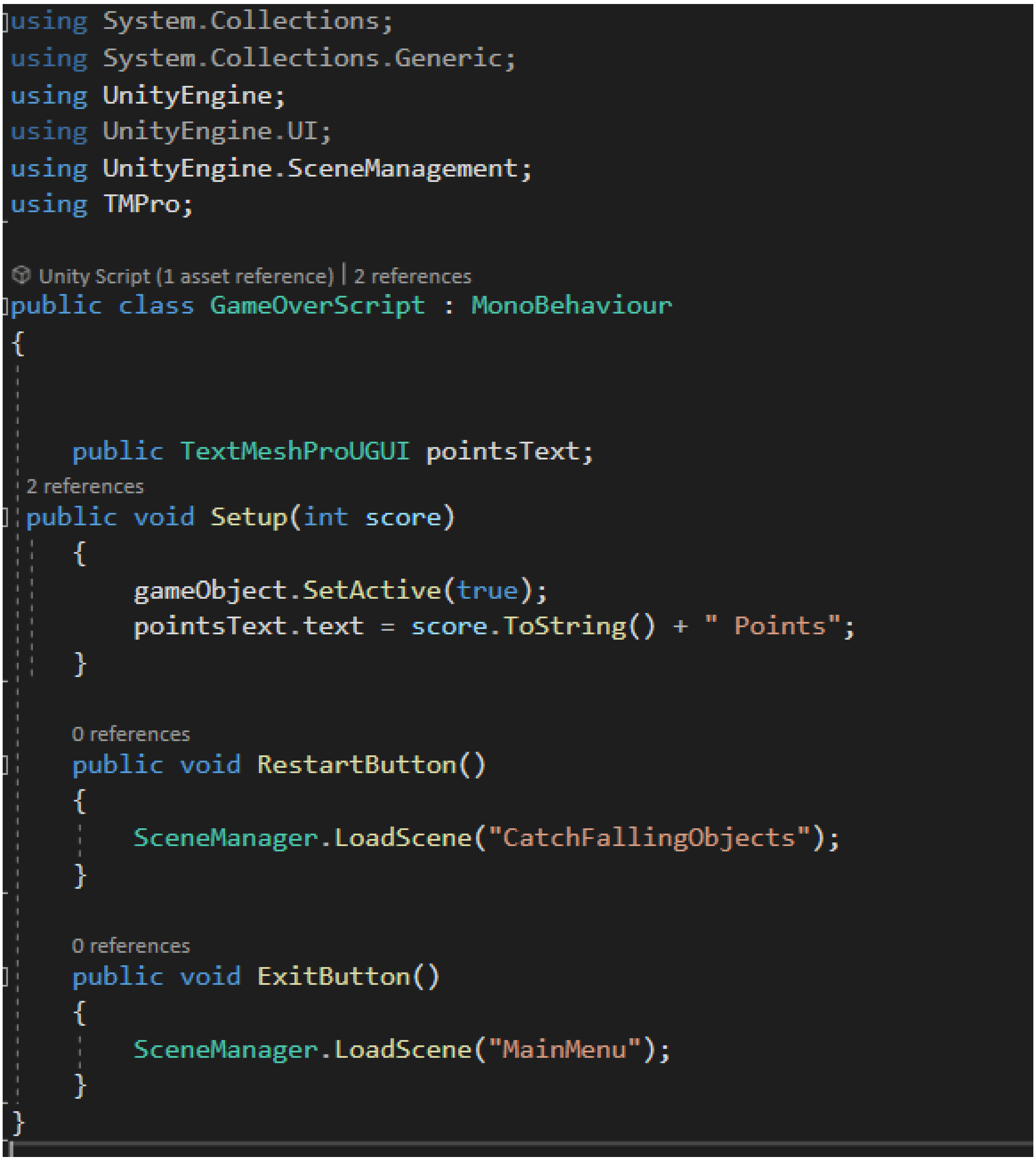
Game Control



```
0 references
public void GoToStage2()
{
    Tutorial1.SetActive(false);
    Tutorial2.SetActive(true);
}

0 references
public void GoToStage3()
{
    Tutorial2.SetActive(false);
    Tutorial3.SetActive(true);
}

0 references
public void GoToStage4()
{
    Tutorial3.SetActive(false);
    Tutorial4.SetActive(true);
}

0 references
public void BackToStage1()
{
    Tutorial1.SetActive(true);
    Tutorial2.SetActive(false);
}

0 references
public void BackToStage2()
{
    Tutorial2.SetActive(true);
    Tutorial3.SetActive(false);
}

0 references
public void BackToStage3()
{
    Tutorial3.SetActive(true);
    Tutorial4.SetActive(false);
```

Figure 5.42: Script for Tutorial controls

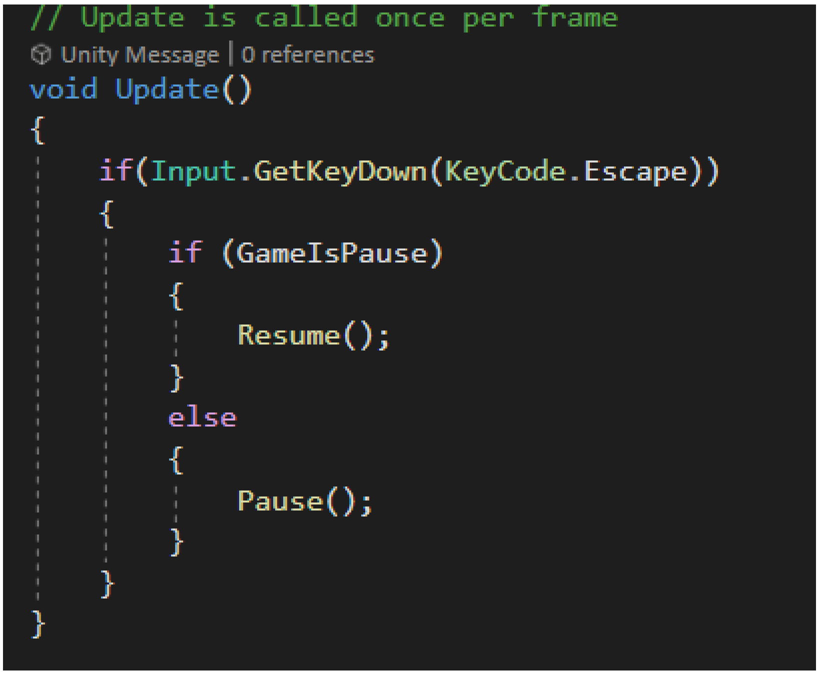
The tutorial on each game is being control using different functions.



```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UI;
using UnityEngine.SceneManagement;
using TMPro;

Unity Script (1 asset reference) | 2 references
public class GameOverScript : MonoBehaviour
{


    public TextMeshProUGUI pointsText;
  2 references
  public void Setup(int score)
    {
        gameObject.SetActive(true);
        pointsText.text = score.ToString() + " Points";
    }

    0 references
    public void RestartButton()
    {
        SceneManager.LoadScene("CatchFallingObjects");
    }

    0 references
    public void ExitButton()
    {
        SceneManager.LoadScene("MainMenu");
    }
}
```

Figure 5.43: Script for Game over

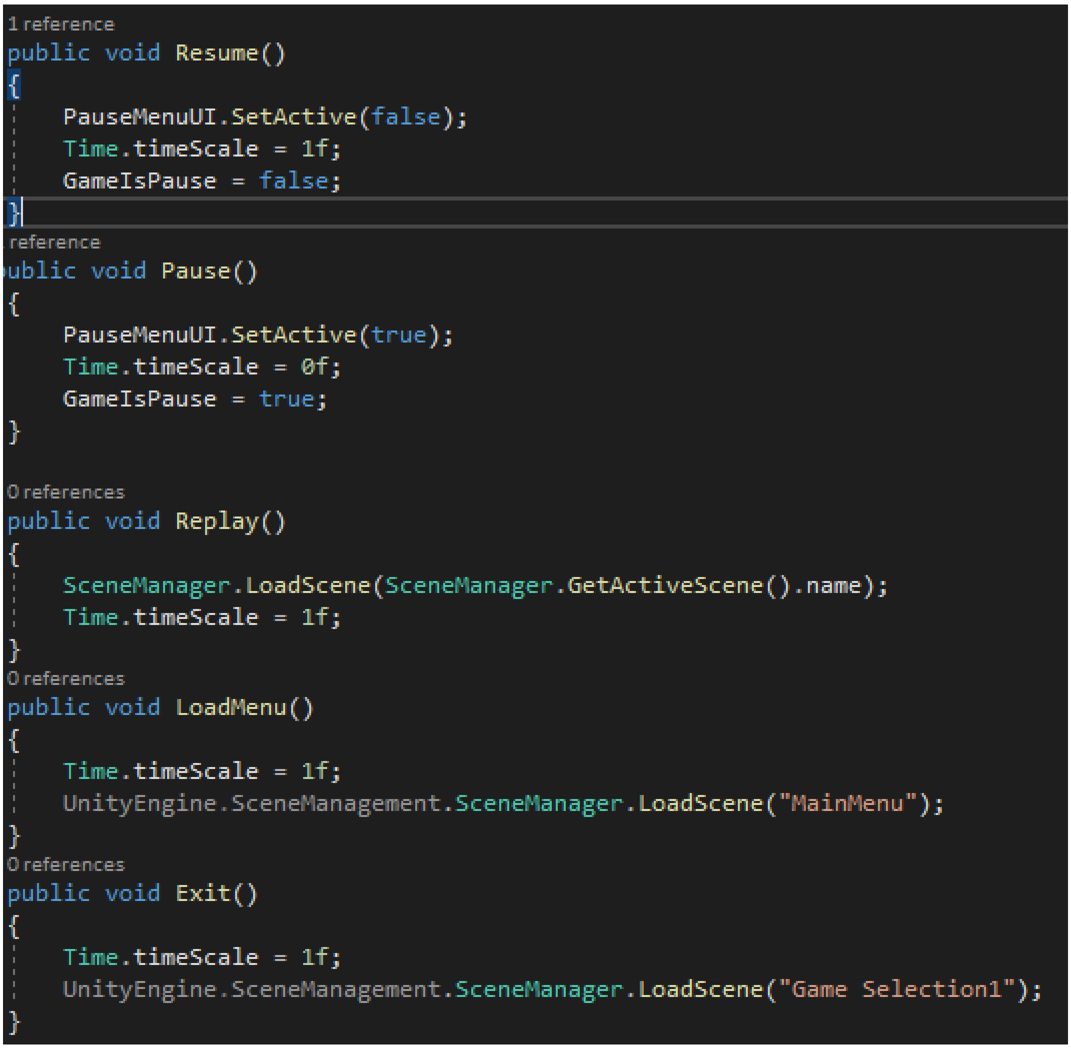
If the game is over, the game over scripts will be executed. The score will be displayed, and the player will have the option to restart or exit the game.



```
// Update is called once per frame
Unity Message | 0 references
void Update()
{
    if(Input.GetKeyDown(KeyCode.Escape))
    {
        if (GameIsPause)
        {
            Resume();
        }
        else
        {
            Pause();
        }
    }
}
```

Figure 5.44: Script for pause game using Esc Key

Players can pause and resume the game by pressing ‘Esc’ key.

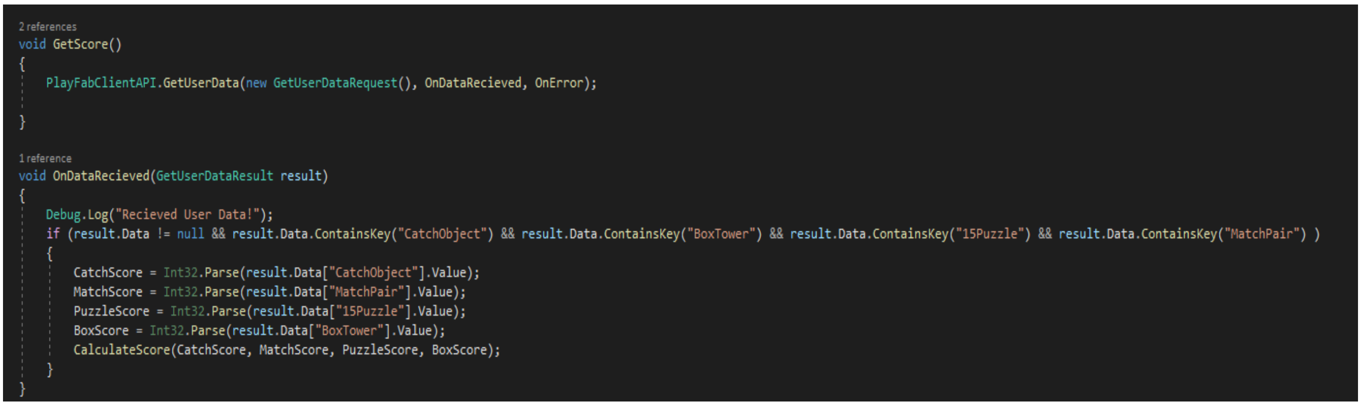


```
1 reference
public void Resume()
{
    PauseMenuUI.SetActive(false);
    Time.timeScale = 1f;
    GameIsPause = false;
}
reference
ublic void Pause()
{
    PauseMenuUI.SetActive(true);
    Time.timeScale = 0f;
    GameIsPause = true;
}

0 references
public void Replay()
{
    SceneManager.LoadScene(SceneManager.GetActiveScene().name);
    Time.timeScale = 1f;
}
0 references
public void LoadMenu()
{
    Time.timeScale = 1f;
    UnityEngine.SceneManagement.SceneManager.LoadScene("MainMenu");
}
0 references
public void Exit()
{
    Time.timeScale = 1f;
    UnityEngine.SceneManagement.SceneManager.LoadScene("Game Selection1");
}
```

Figure 5.45: Script for pause, resume, restart, quit game

If the game is paused, the pause menu appears and the game freezes. The player has the option of replaying the game, returning to the main menu, or exiting the game.

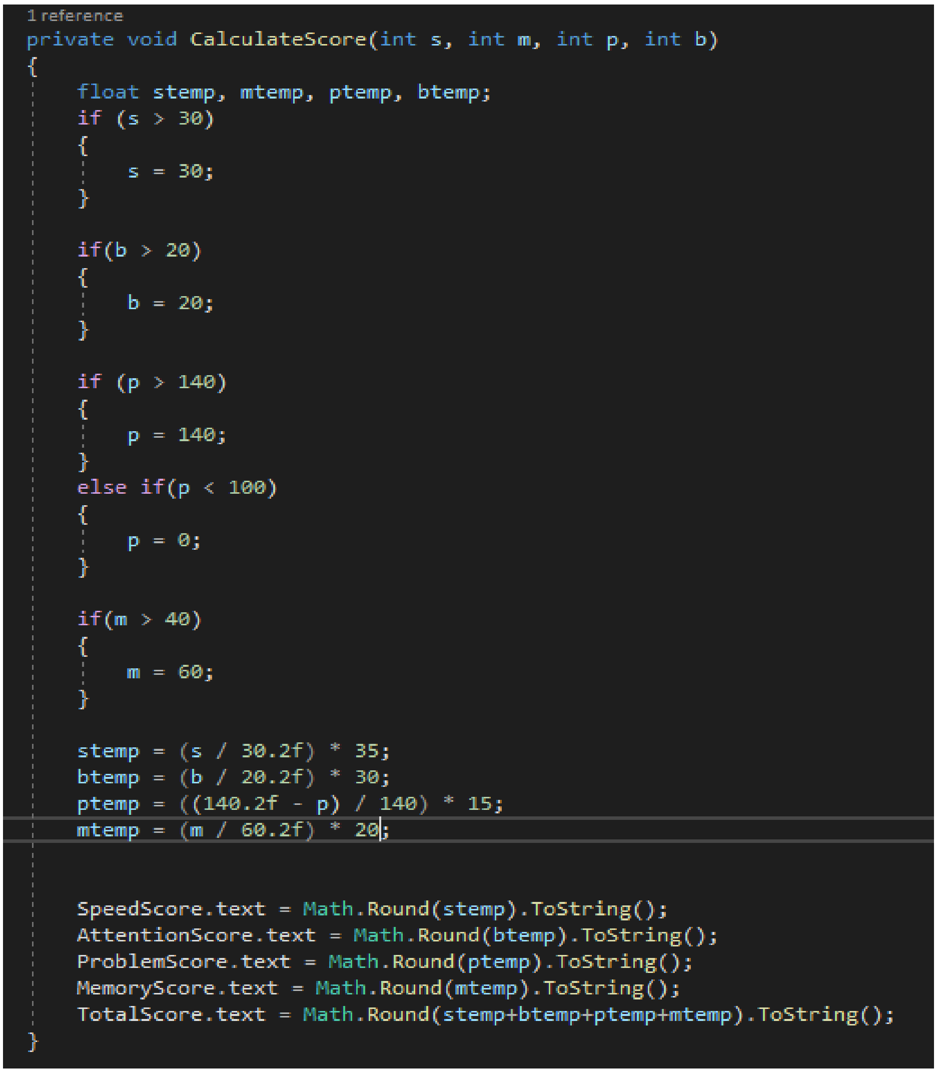
Cognitive Score



```
2 references
void GetScore()
{
    PlayFabClientAPI.GetUserData(new GetUserDataRequest(), OnDataRecieved, OnError);

}

1 reference
void OnDataRecieved(GetUserDataResult result)
{
    Debug.Log("Recieved User Data!");
    if (result.Data != null && result.Data.ContainsKey("CatchObject") && result.Data.ContainsKey("BoxTower") && result.Data.ContainsKey("15Puzzle") && result.Data.ContainsKey("MatchPair") )
    {
        CatchScore = Int32.Parse(result.Data["CatchObject"].Value);
        MatchScore = Int32.Parse(result.Data["MatchPair"].Value);
        PuzzleScore = Int32.Parse(result.Data["15Puzzle"].Value);
        BoxScore = Int32.Parse(result.Data["BoxTower"].Value);
        CalculateScore(CatchScore, MatchScore, PuzzleScore, BoxScore);
    }
}
```

Figure 5.46: Script for get user data

The cognitive score is determined by the four game categories: speed, attention, memory, and problem solving. GetUserData is a method for retrieving user data from PlayFab. The information is then used to compute the cognitive score for each category as well as the overall cognitive score.



```
1 reference
private void CalculateScore(int s, int m, int p, int b)
{
    float stemp, mtemp, ptemp, btemp;
    if (s > 30)
    {
        s = 30;
    }

    if(b > 20)
    {
        b = 20;
    }

    if (p > 140)
    {
        p = 140;
    }
    else if(p < 100)
    {
        p = 0;
    }

    if(m > 40)
    {
        m = 60;
    }

    stemp = (s / 30.2f) * 35;
    btemp = (b / 20.2f) * 30;
    ptemp = ((140.2f - p) / 140) * 15;
    mtemp = (m / 60.2f) * 20;


    SpeedScore.text = Math.Round(stemp).ToString();
    AttentionScore.text = Math.Round(btemp).ToString();
    ProblemScore.text = Math.Round(ptemp).ToString();
    MemoryScore.text = Math.Round(mtemp).ToString();
    TotalScore.text = Math.Round(stemp+btemp+ptemp+mtemp).ToString();
}
```

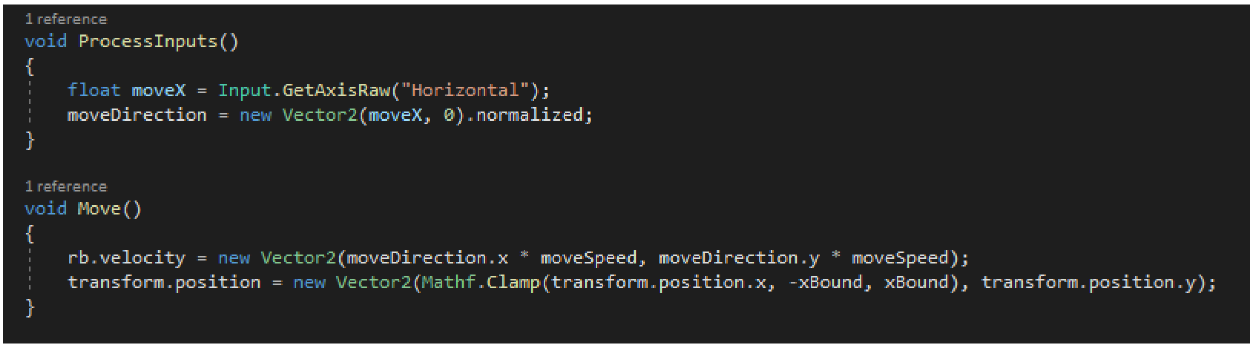
Figure 5.47: Script for calculate cognitive score

The CalculateScore function is used to compute a player's performance and cognitive score. The scoring matrix for each game is listed below in the table:

Degree Game	Normal	Mild Dementia	Severe Dementia
CatchFalling Object	>30	10-30	<10
Box Tower	>20	10-19	<10
15Puzzle (Seconds)	<100 sec	101 – 140 sec	>140 sec
Matching Pair (seconds left)	>20 Sec	1-20 sec	0 sec

Table 5.8: Games scoring matrix

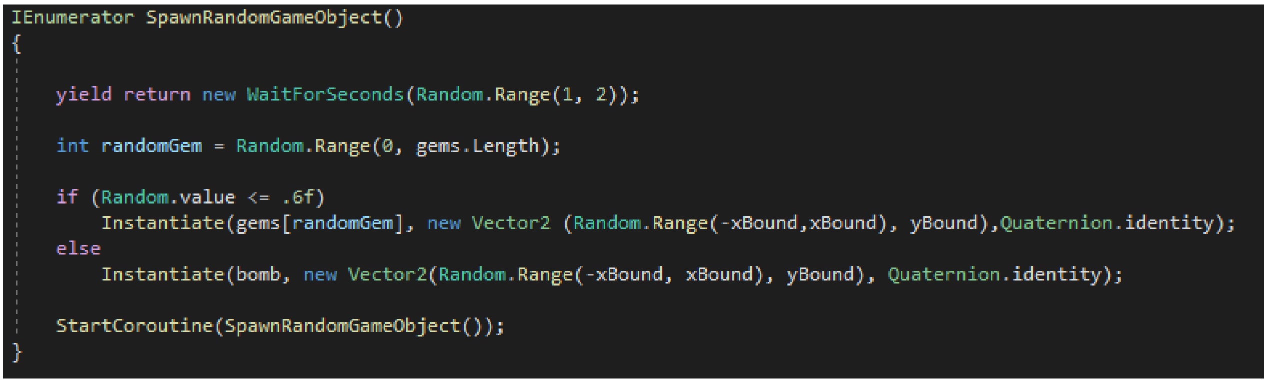
Catch Object



```
1 reference
void ProcessInputs()
{
    float moveX = Input.GetAxisRaw("Horizontal");
    moveDirection = new Vector2(moveX, 0).normalized;
}

1 reference
void Move()
{
    rb.velocity = new Vector2(moveDirection.x * moveSpeed, moveDirection.y * moveSpeed);
    transform.position = new Vector2(Mathf.Clamp(transform.position.x, -xBound, xBound), transform.position.y);
}
```

Figure 5.48: Script for character movement

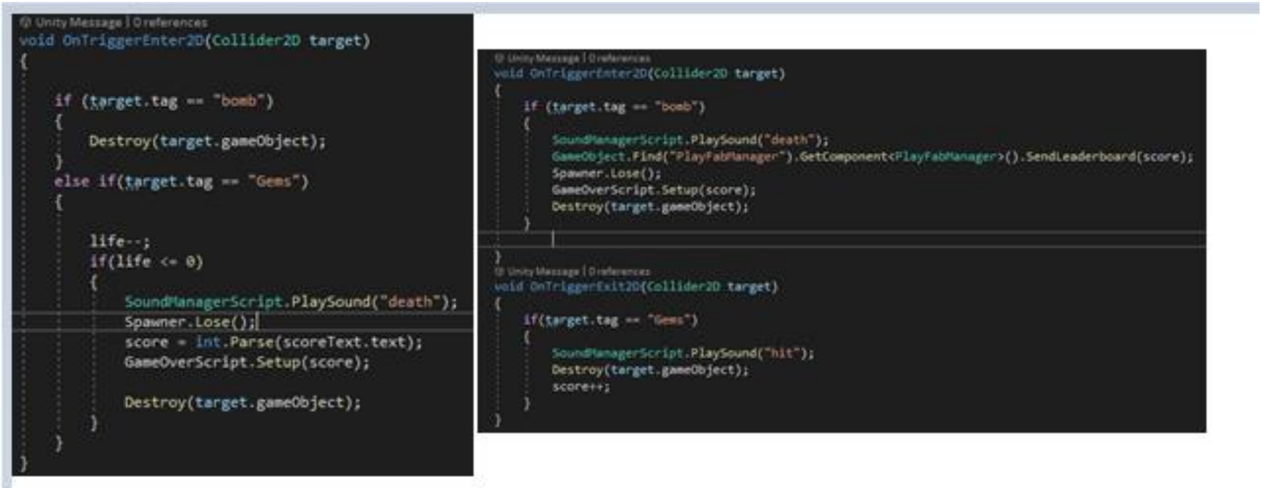
The above code will take in user input and change the character movement based on Unity physics engine.



```
IEnumerator SpawnRandomGameObject()
{

    yield return new WaitForSeconds(Random.Range(1, 2));

    int randomGem = Random.Range(0, gems.Length);

    if (Random.value <= .6f)
        Instantiate(gems[randomGem], new Vector2 (Random.Range(-xBound,xBound), yBound),Quaternion.identity);
    else
        Instantiate(bomb, new Vector2(Random.Range(-xBound, xBound), yBound), Quaternion.identity);

    StartCoroutine(SpawnRandomGameObject());
}
```

Figure 5.49: Scripts for object spawner

The above code will cause the object spawns in a random order.



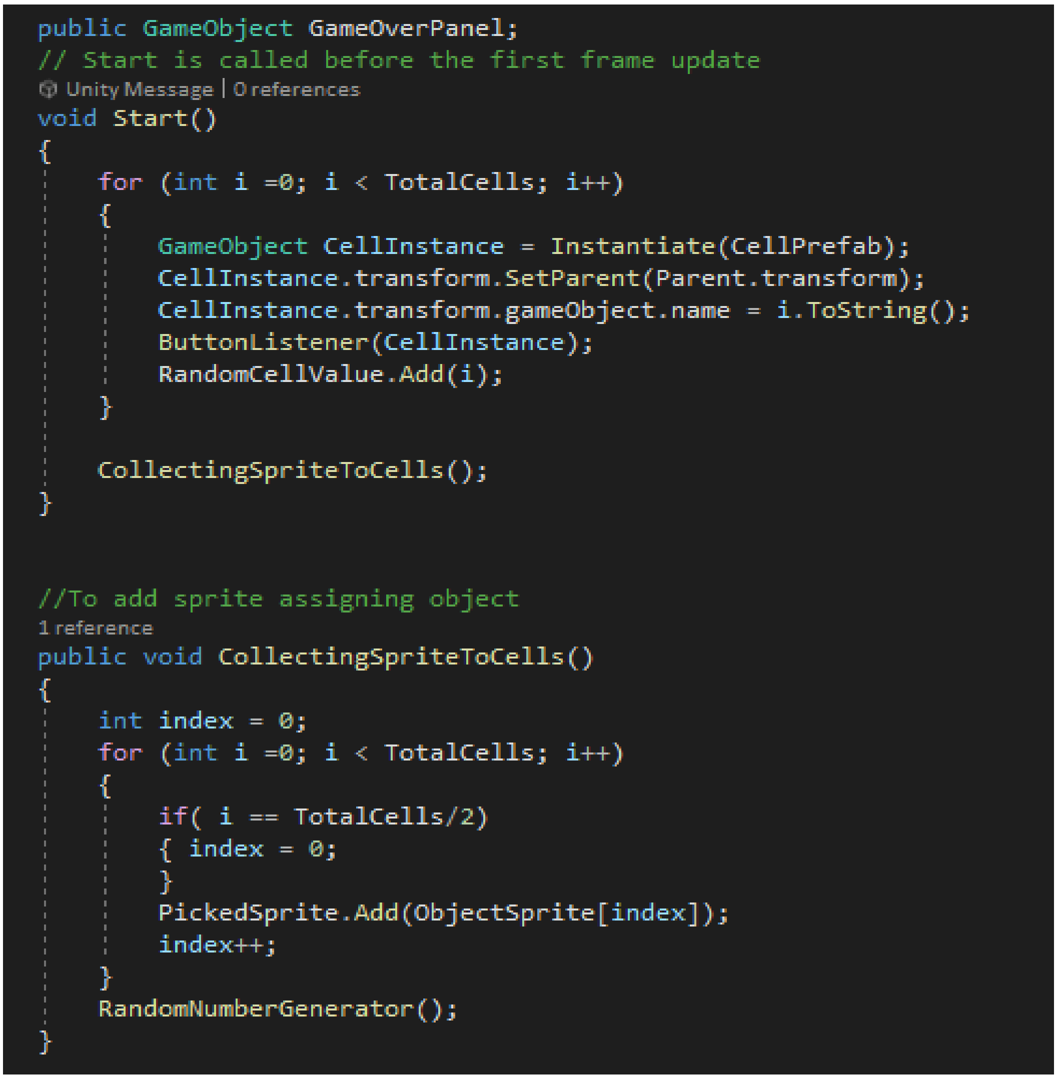
```
Unity Message | 0 references
void OnTriggerEnter2D(Collider2D target)
{

    if (target.tag == "bomb")
    {
        Destroy(target.gameObject);
    }
    else if(target.tag == "Gems")
    {

        life--;
        if(life <= 0)
        {
            SoundManagerScript.PlaySound("death");
            Spawner.Lose();
            score = int.Parse(scoreText.text);
            GameOverScript.Setup(score);

            Destroy(target.gameObject);
        }
    }
}
```

```
Unity Message | 0 references
void OnTriggerEnter2D(Collider2D target)
{
    if (target.tag == "bomb")
    {
        SoundManagerScript.PlaySound("death");
        GameObject.Find("PlayFabManager").GetComponent<PlayFabManager>().SendLeaderboard(score);
        Spawner.Lose();
        GameOverScript.Setup(score);
        Destroy(target.gameObject);
    }

}
Unity Message | 0 references
void OnTriggerExit2D(Collider2D target)
{
    if(target.tag == "Gems")
    {
        SoundManagerScript.PlaySound("hit");
        Destroy(target.gameObject);
        score++;
    }
}
```

Figure 5.50: Scripts for game logic

The above code will kill the character if the character catch a bomb or the character missed 3 valid objects. The player's score will add if they caught a valid object.

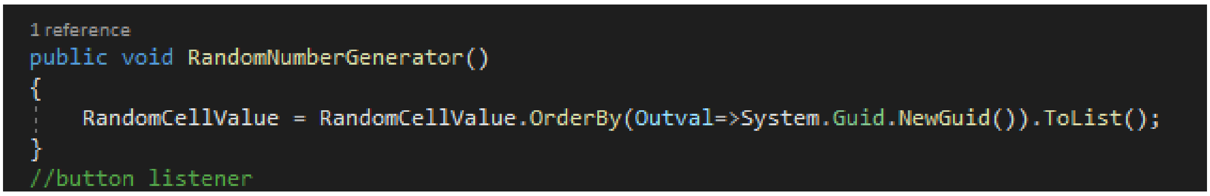
Matching Pair



```
public GameObject GameOverPanel;
// Start is called before the first frame update
Unity Message | 0 references
void Start()
{
    for (int i =0; i < TotalCells; i++)
    {
        GameObject CellInstance = Instantiate(CellPrefab);
        CellInstance.transform.SetParent(Parent.transform);
        CellInstance.transform.gameObject.name = i.ToString();
        ButtonListener(CellInstance);
        RandomCellValue.Add(i);
    }

    CollectingSpriteToCells();
}


//To add sprite assigning object
1 reference
public void CollectingSpriteToCells()
{
    int index = 0;
    for (int i =0; i < TotalCells; i++)
    {
        if( i == TotalCells/2)
        { index = 0;
        }
        PickedSprite.Add(ObjectSprite[index]);
        index++;
    }
    RandomNumberGenerator();
}
```

Figure 5.51: Scripts for cards initialisation

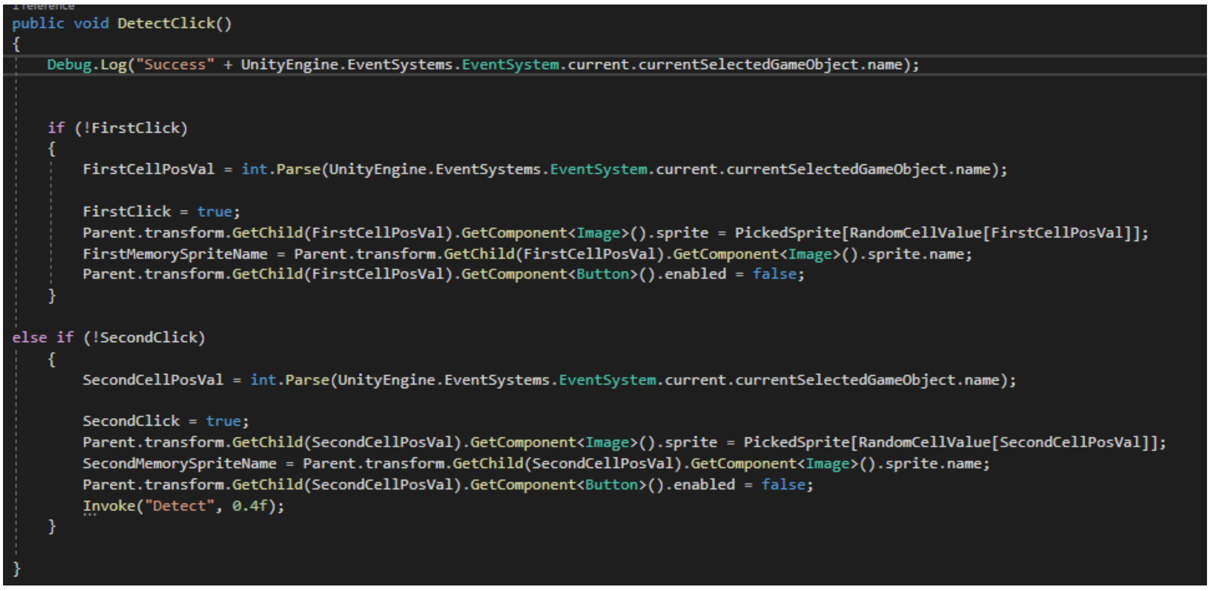
To begin, the game will collect sprites and duplicate them to create pairs of cards. The order of the cards will be shuffled using RandomNumberGenerator().



```
1 reference
public void RandomNumberGenerator()
{
    RandomCellValue = RandomCellValue.OrderBy(Outval=>System.Guid.NewGuid()).ToList();
}
//button listener
```

Figure 5.52: Scripts for RNG function

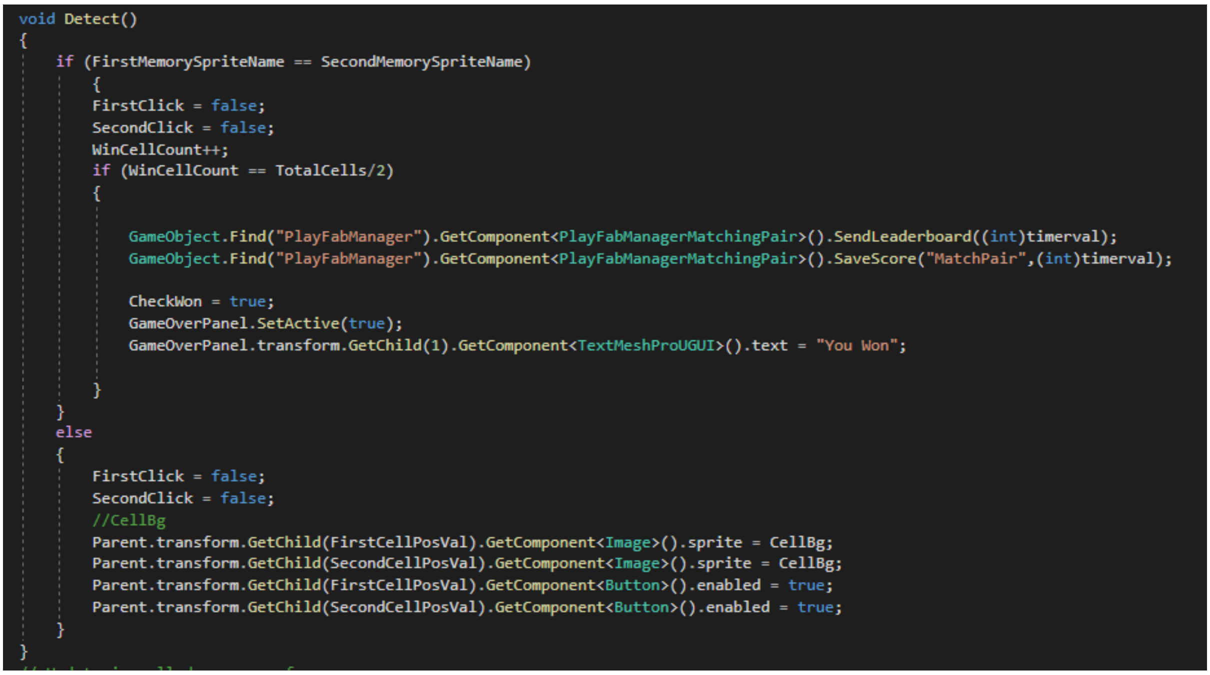
The cards order are shuffled using RandomNumberGenerator function.



```
public void DetectClick()
{
    Debug.Log("Success" + UnityEngine.EventSystems.EventSystem.current.currentSelectedGameObject.name);


    if (!FirstClick)
    {
        FirstCellPosVal = int.Parse(UnityEngine.EventSystems.EventSystem.current.currentSelectedGameObject.name);

        FirstClick = true;
        Parent.transform.GetChild(FirstCellPosVal).GetComponent<Image>().sprite = PickedSprite[RandomCellValue[FirstCellPosVal]];
        FirstMemorySpriteName = Parent.transform.GetChild(FirstCellPosVal).GetComponent<Image>().sprite.name;
        Parent.transform.GetChild(FirstCellPosVal).GetComponent<Button>().enabled = false;
    }

else if (!SecondClick)
    {
        SecondCellPosVal = int.Parse(UnityEngine.EventSystems.EventSystem.current.currentSelectedGameObject.name);

        SecondClick = true;
        Parent.transform.GetChild(SecondCellPosVal).GetComponent<Image>().sprite = PickedSprite[RandomCellValue[SecondCellPosVal]];
        SecondMemorySpriteName = Parent.transform.GetChild(SecondCellPosVal).GetComponent<Image>().sprite.name;
        Parent.transform.GetChild(SecondCellPosVal).GetComponent<Button>().enabled = false;
        Invoke("Detect", 0.4f);
    }

}
```

Figure 5.53: Scripts for detect user input

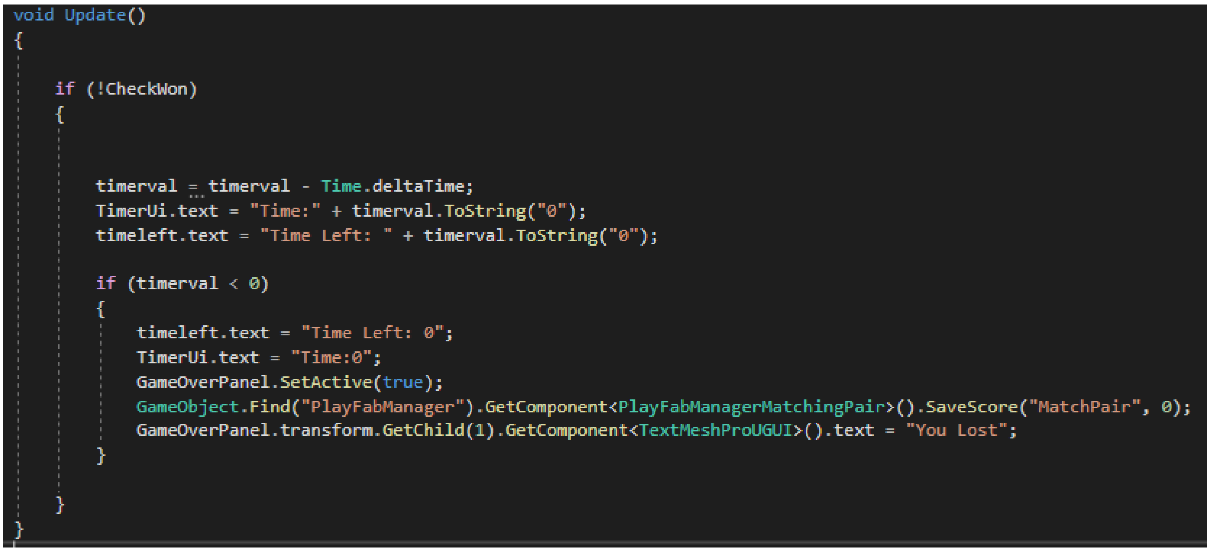
The DetectClick receives user input and determines how many cards can be folded open at once. At any given time, only two cards (firstclick and secondclick) can be folded open. If two cards are folded open, the game will use the Detect function to see if they are the same pair.



```
void Detect()
{
    if (FirstMemorySpriteName == SecondMemorySpriteName)
        {
        FirstClick = false;
        SecondClick = false;
        WinCellCount++;
        if (WinCellCount == TotalCells/2)
        {

            GameObject.Find("PlayFabManager").GetComponent<PlayFabManagerMatchingPair>().SendLeaderboard((int)timerval);
            GameObject.Find("PlayFabManager").GetComponent<PlayFabManagerMatchingPair>().SaveScore("MatchPair",(int)timerval);

            CheckWon = true;
            GameOverPanel.SetActive(true);
            GameOverPanel.transform.GetChild(1).GetComponent<TextMeshProUGUI>().text = "You Won";

        }
    }
    else
    {
        FirstClick = false;
        SecondClick = false;
        //CellBg
        Parent.transform.GetChild(FirstCellPosVal).GetComponent<Image>().sprite = CellBg;
        Parent.transform.GetChild(SecondCellPosVal).GetComponent<Image>().sprite = CellBg;
        Parent.transform.GetChild(FirstCellPosVal).GetComponent<Button>().enabled = true;
        Parent.transform.GetChild(SecondCellPosVal).GetComponent<Button>().enabled = true;
    }
}
```

Figure 5.54: Scripts for game logic

If two cards form the same pair, the WinCellCount will increase by one until all pairs are found, at which point the game will end. If two cards do not form the same pair, the cards will be fold.

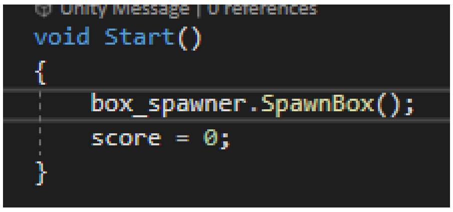


```
void Update()
{

    if (!CheckWon)
    {


        timerval = timerval - Time.deltaTime;
        TimerUi.text = "Time:" + timerval.ToString("0");
        timeleft.text = "Time Left: " + timerval.ToString("0");

        if (timerval < 0)
        {
            timeleft.text = "Time Left: 0";
            TimerUi.text = "Time:0";
            GameOverPanel.SetActive(true);
            GameObject.Find("PlayFabManager").GetComponent<PlayFabManagerMatchingPair>().SaveScore("MatchPair", 0);
            GameOverPanel.transform.GetChild(1).GetComponent<TextMeshProUGUI>().text = "You Lost";
        }

    }
}
```

Figure 5.55: Scripts for checking game won

The game will check if the game is won every second. If the timer runs out in 60 seconds, the game will automatically end.

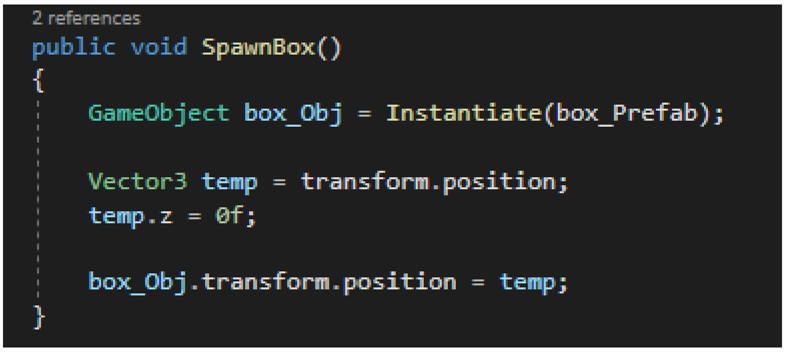
Box Tower



```
Unity Message | 0 references
void Start()
{
    box_spawner.SpawnBox();
    score = 0;
}
```

Figure 5.56: Scripts for spawn box at start

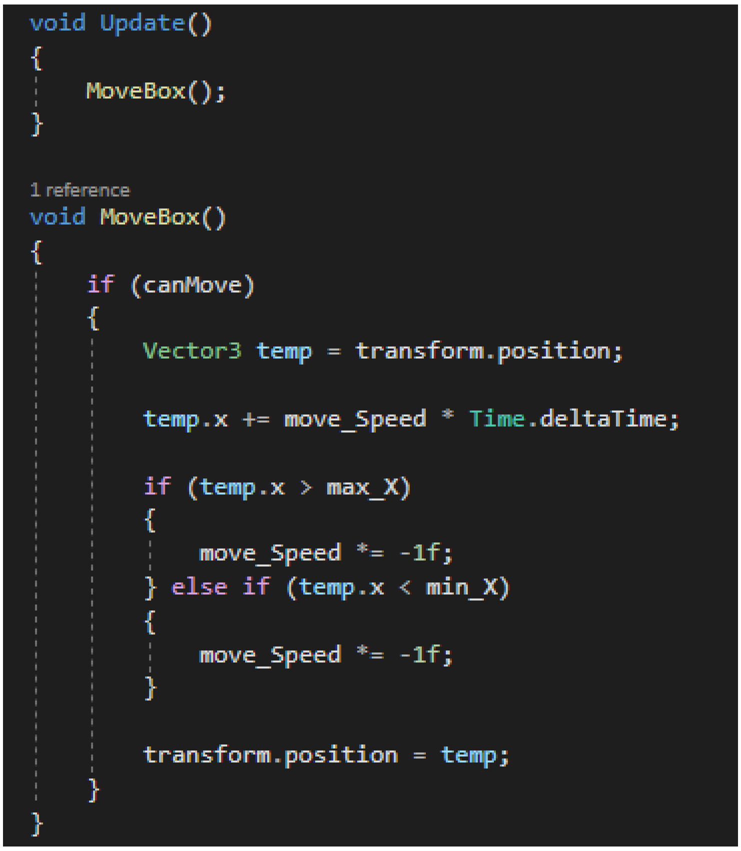
The game will spawn a box and set the score to 0 at the start of the game.



```
2 references
public void SpawnBox()
{
    GameObject box_Obj = Instantiate(box_Prefab);

    Vector3 temp = transform.position;
    temp.z = 0f;

    box_Obj.transform.position = temp;
}
```

Figure 5.57: Scripts for spawn box

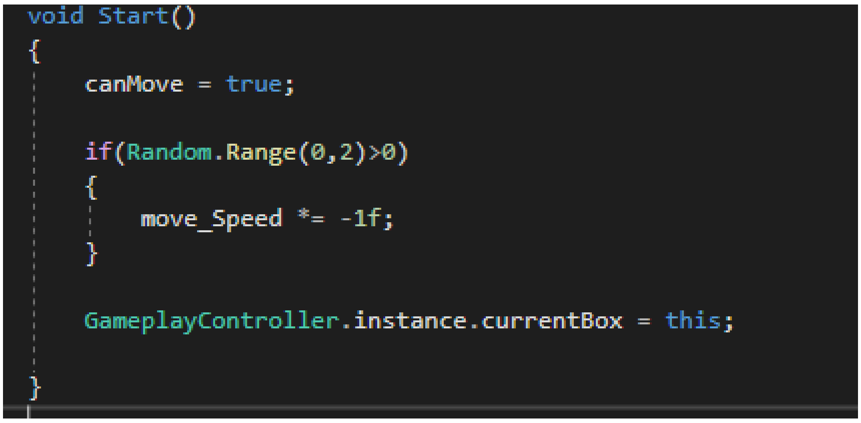
In the middle of the game scene, the SpawnBox function will generate a new box game object.



```
void Update()
{
    MoveBox();
}

1 reference
void MoveBox()
{
    if (canMove)
    {
        Vector3 temp = transform.position;

        temp.x += move_Speed * Time.deltaTime;

        if (temp.x > max_X)
        {
            move_Speed *= -1f;
        } else if (temp.x < min_X)
        {
            move_Speed *= -1f;
        }

        transform.position = temp;
    }
}
```

Figure 5.58: Scripts for move box

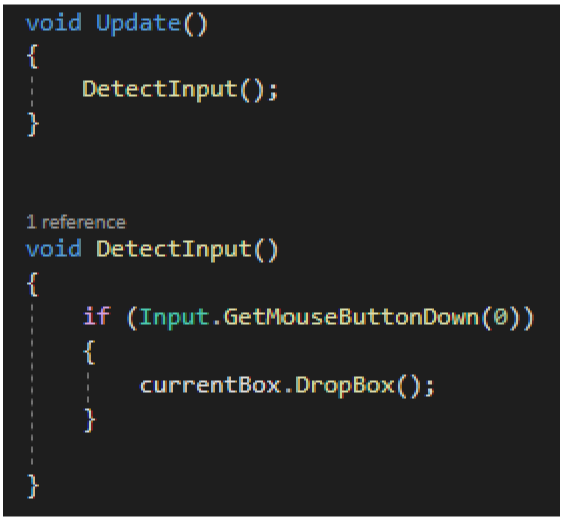
Within the confines of the screen, the box will move at a constant speed to the left and right.



```
void Start()
{
    canMove = true;

    if(Random.Range(0,2)>0)
    {
        move_Speed *= -1f;
    }

    GameplayController.instance.currentBox = this;

}
```

Figure 5.59: Scripts for checking box movement

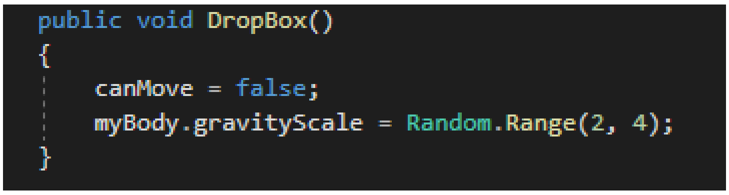
The box will move at the constant speed.



```
void Update()
{
    DetectInput();
}


1 reference
void DetectInput()
{
    if (Input.GetMouseButtonDown(0))
    {
        currentBox.DropBox();
    }

}
```

Figure 5.60: Scripts for detect user input and drop box

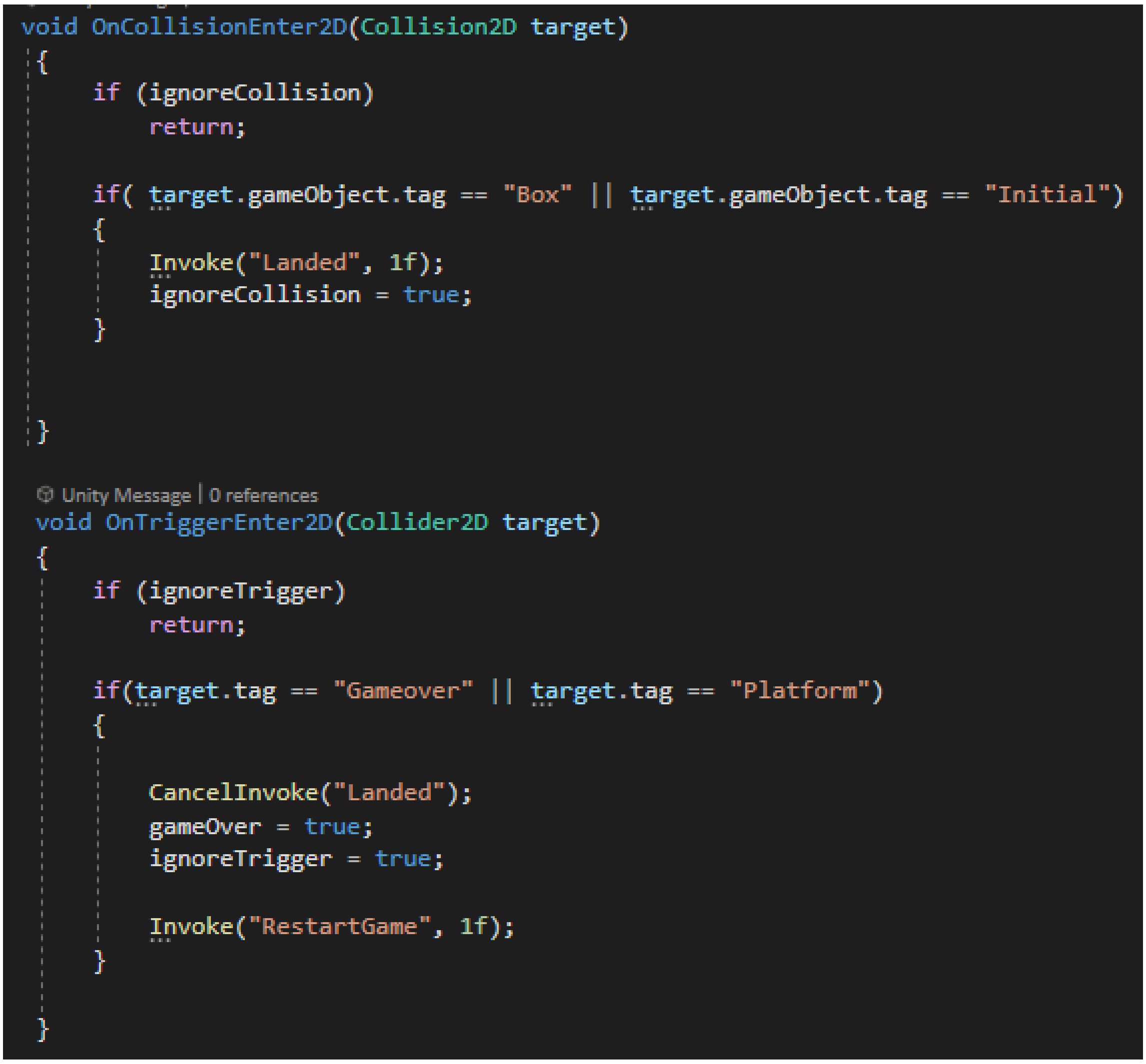
The box will be dropped if user input is detected.



```
public void DropBox()
{
    canMove = false;
    myBody.gravityScale = Random.Range(2, 4);
}
```

Figure 5.61: Scripts for drop box

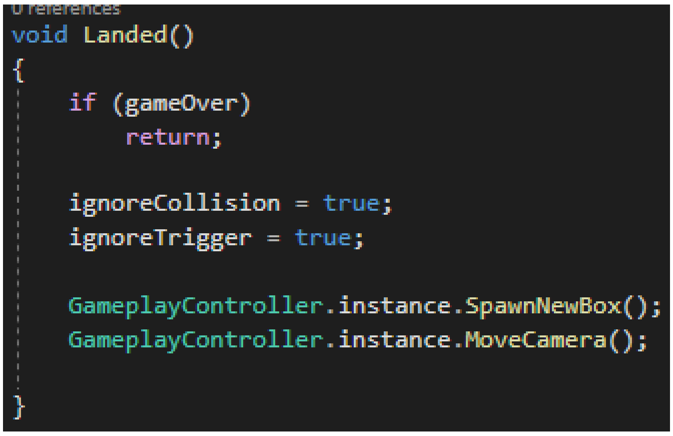
When the box is dropped, the left and right movement is disabled.



```
void OnCollisionEnter2D(Collision2D target)
{
    if (ignoreCollision)
        return;

    if( target.gameObject.tag == "Box" || target.gameObject.tag == "Initial")
    {
        Invoke("Landed", 1f);
        ignoreCollision = true;
    }


}

Unity Message | 0 references
void OnTriggerEnter2D(Collider2D target)
{
    if (ignoreTrigger)
        return;

    if(target.tag == "Gameover" || target.tag == "Platform")
    {

        CancelInvoke("Landed");
        gameOver = true;
        ignoreTrigger = true;

        Invoke("RestartGame", 1f);
    }

}
```

Figure 5.62: Scripts for checking object interection

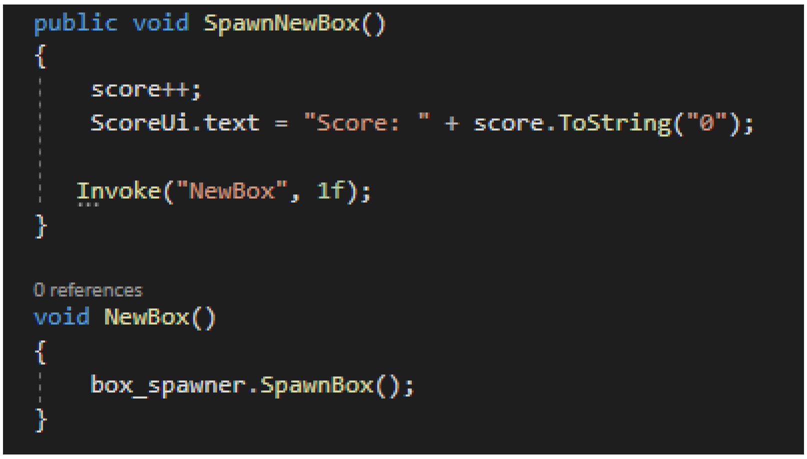
If the box lands on another box, the Landed function is invoked. The game is over if the box does not land on another box.



```
0 references
void Landed()
{
    if (gameOver)
        return;

    ignoreCollision = true;
    ignoreTrigger = true;

    GameplayController.instance.SpawnNewBox();
    GameplayController.instance.MoveCamera();

}
```

Figure 5.63: Scripts for logic after box landed

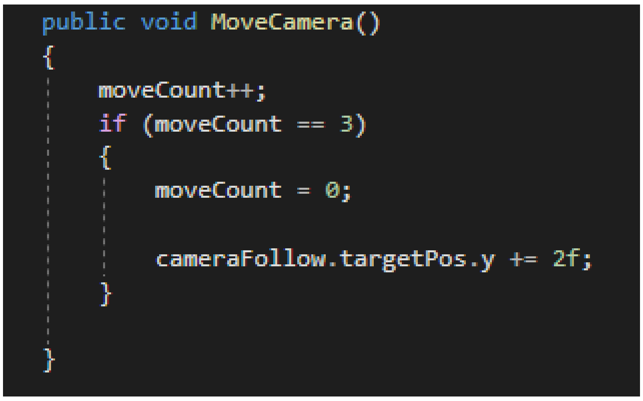
The Landed function will spawn another box and move the camera.



```
public void SpawnNewBox()
{
    score++;
    ScoreUi.text = "Score: " + score.ToString("0");

   Invoke("NewBox", 1f);
}

0 references
void NewBox()
{
    box_spawner.SpawnBox();
}
```

Figure 5.64: Scripts for spawn new box

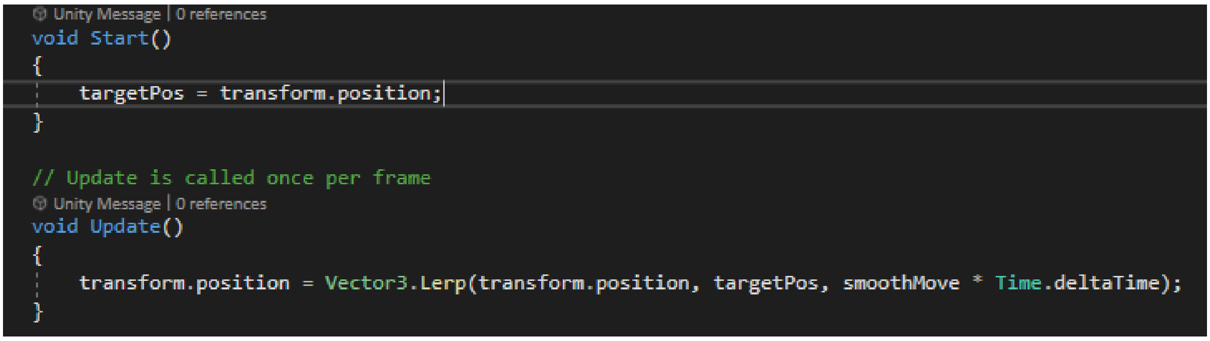
If box is spawned, the score will increase by 1.



```
public void MoveCamera()
{
    moveCount++;
    if (moveCount == 3)
    {
        moveCount = 0;

        cameraFollow.targetPos.y += 2f;
    }

}
```

Figure 5.65: Scripts for checking moving camera

If the box is stacked 3 times, camera will move upwards.

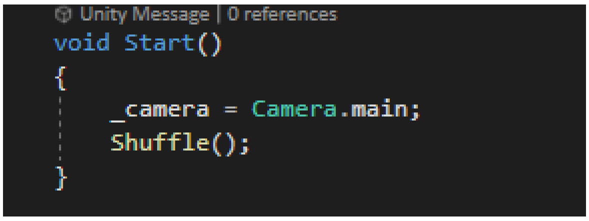


```
Unity Message | 0 references
void Start()
{
    targetPos = transform.position;
}

// Update is called once per frame
Unity Message | 0 references
void Update()
{
    transform.position = Vector3.Lerp(transform.position, targetPos, smoothMove * Time.deltaTime);
}
```

Figure 5.66: Scripts for moving camera

The camera will move using Vector3.Lerp function.

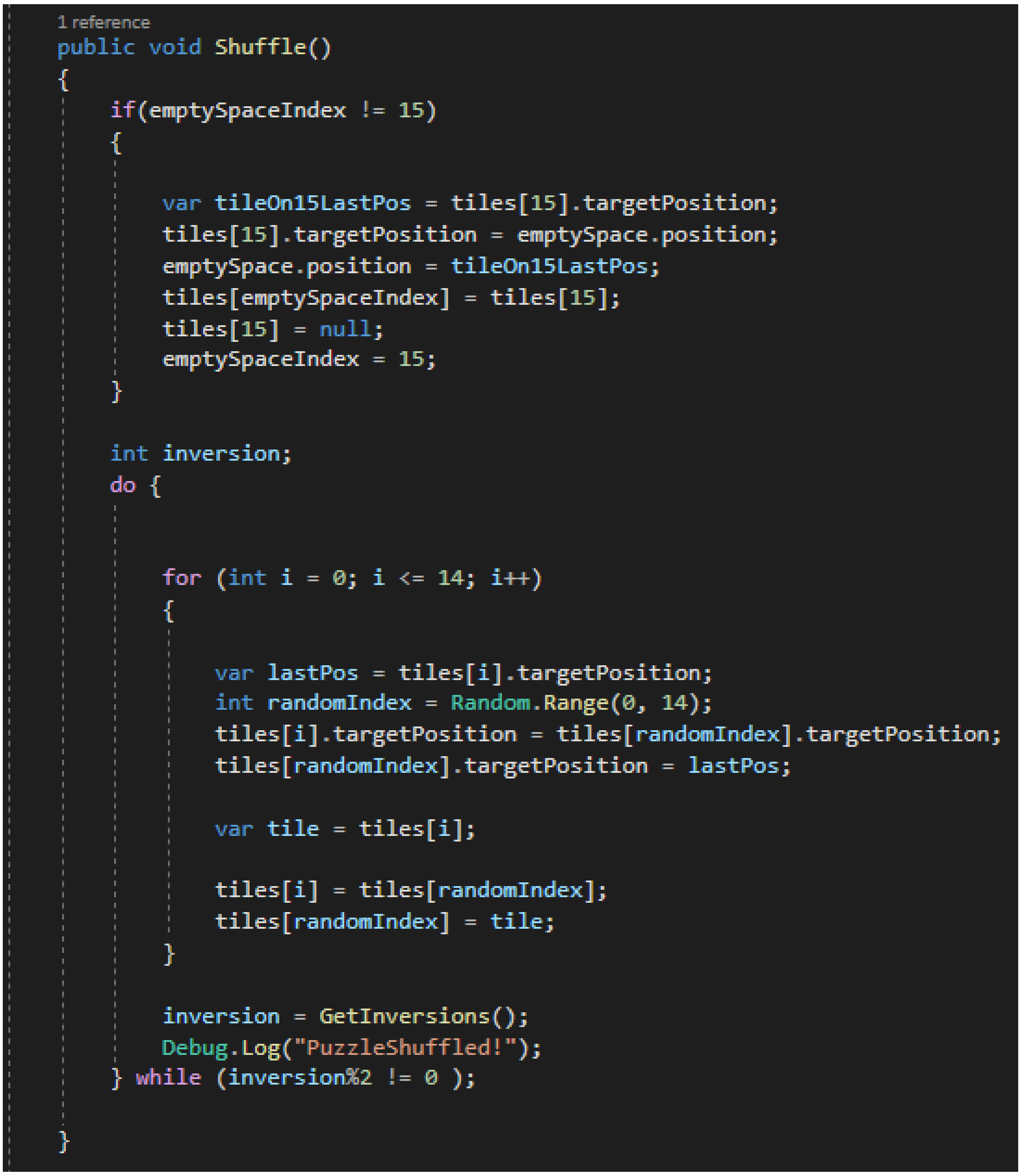
15Puzzle



```
Unity Message | 0 references
void Start()
{
    _camera = Camera.main;
    Shuffle();
}
```

Figure 5.67: Scripts for call shuffle tiles

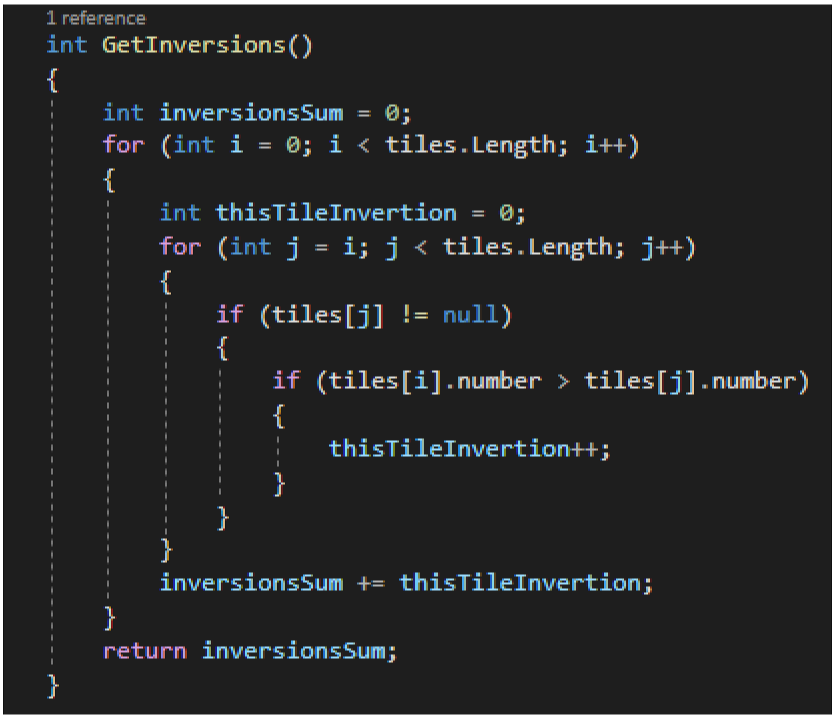
The tiles will be shuffled at the start of the game.



```
1 reference
public void Shuffle()
{
    if(emptySpaceIndex != 15)
    {

        var tileOn15LastPos = tiles[15].targetPosition;
        tiles[15].targetPosition = emptySpace.position;
        emptySpace.position = tileOn15LastPos;
        tiles[emptySpaceIndex] = tiles[15];
        tiles[15] = null;
        emptySpaceIndex = 15;
    }

    int inversion;
    do {


        for (int i = 0; i <= 14; i++)
        {

            var lastPos = tiles[i].targetPosition;
            int randomIndex = Random.Range(0, 14);
            tiles[i].targetPosition = tiles[randomIndex].targetPosition;
            tiles[randomIndex].targetPosition = lastPos;

            var tile = tiles[i];

            tiles[i] = tiles[randomIndex];
            tiles[randomIndex] = tile;
        }

        inversion = GetInversions();
        Debug.Log("PuzzleShuffled!");
    } while (inversion%2 != 0 );

}
```

Figure 5.68: Scripts for shuffle tiles

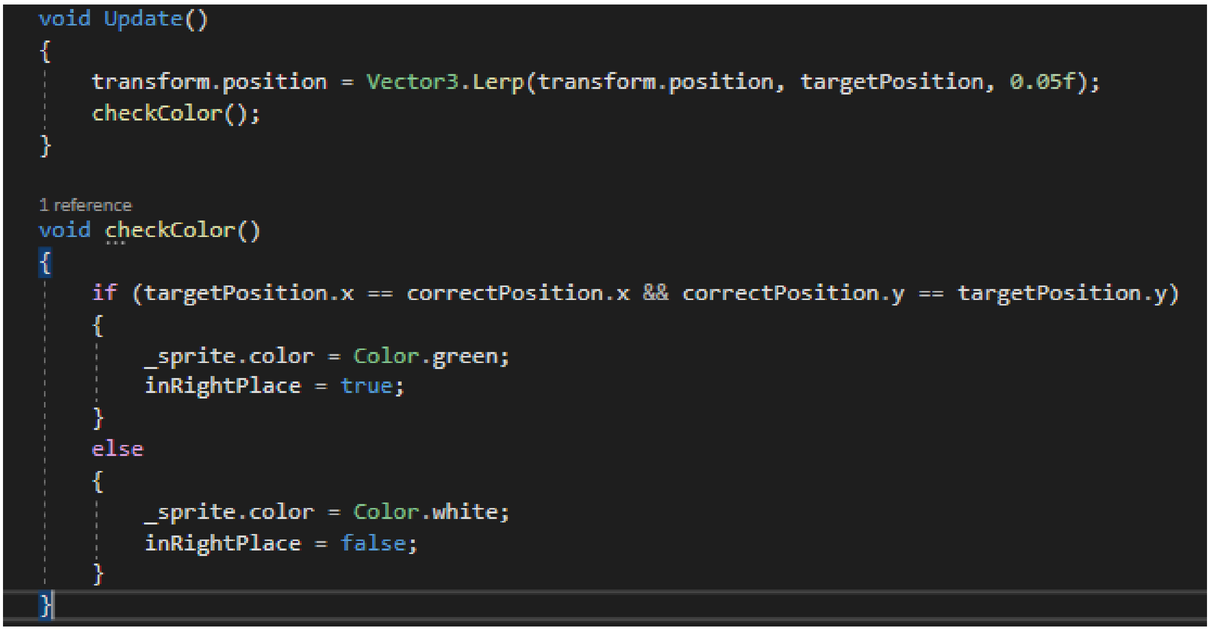
The tiles will first be shuffled using the inversion function. The shuffling will stop if every tile has an inversion value of an even number.



```
1 reference
int GetInversions()
{
    int inversionsSum = 0;
    for (int i = 0; i < tiles.Length; i++)
    {
        int thisTileInvertion = 0;
        for (int j = i; j < tiles.Length; j++)
        {
            if (tiles[j] != null)
            {
                if (tiles[i].number > tiles[j].number)
                {
                    thisTileInvertion++;
                }
            }
        }
        inversionsSum += thisTileInvertion;
    }
    return inversionsSum;
}
```

Figure 5.69: Scripts for inversion

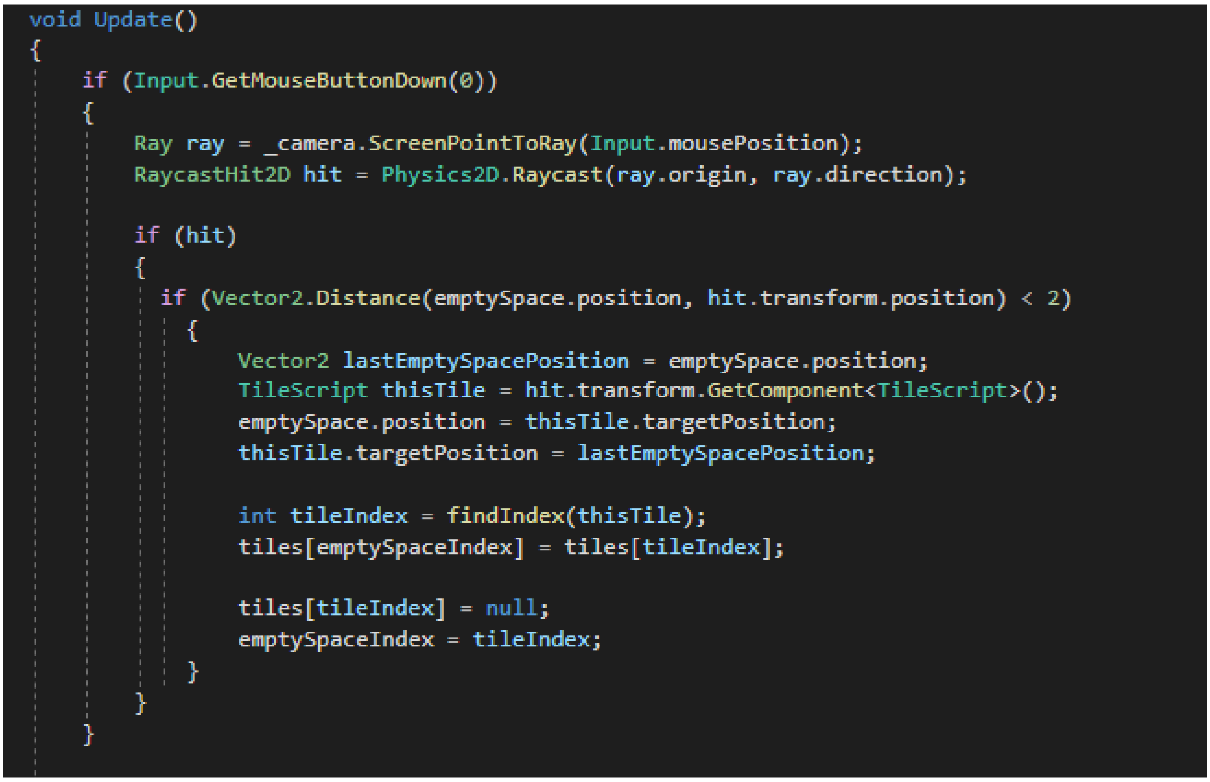
The GetInversion function returns the total number of tiles with values greater than the tile.



```
void Update()
{
    transform.position = Vector3.Lerp(transform.position, targetPosition, 0.05f);
    checkColor();
}

1 reference
void checkColor()
{
    if (targetPosition.x == correctPosition.x && correctPosition.y == targetPosition.y)
    {
        _sprite.color = Color.green;
        inRightPlace = true;
    }
    else
    {
        _sprite.color = Color.white;
        inRightPlace = false;
    }
}
```

Figure 5.70: Scripts for checking tile position

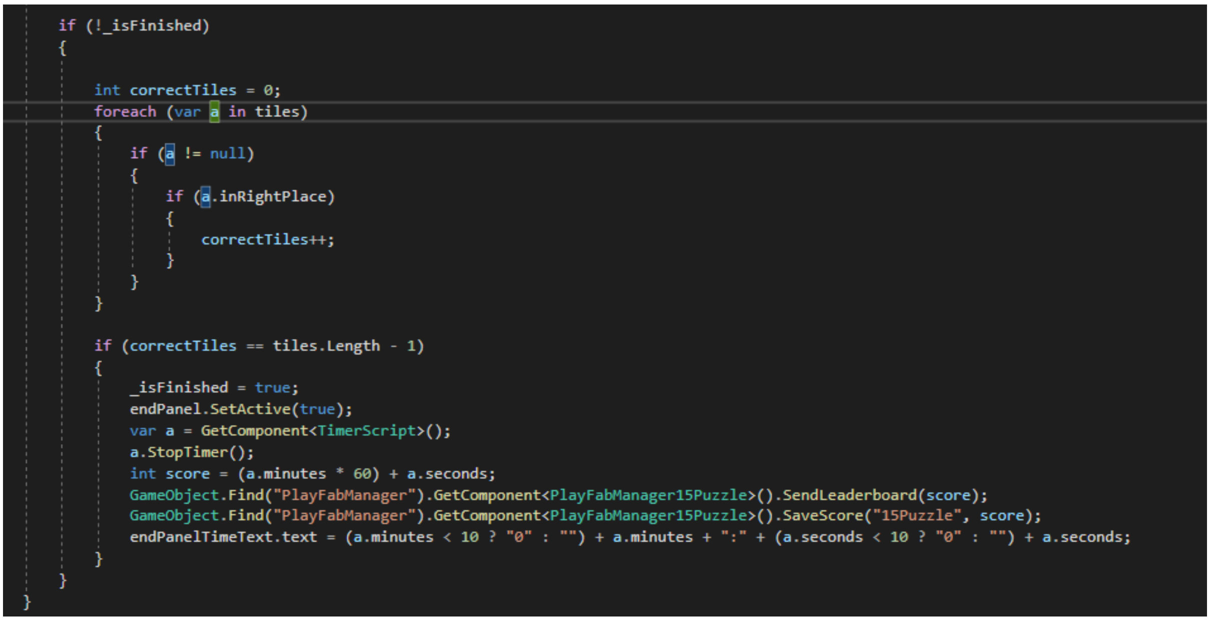
If the tile is in the correct position, it will change colour.



```
void Update()
{
    if (Input.GetMouseButtonDown(0))
    {
        Ray ray = _camera.ScreenPointToRay(Input.mousePosition);
        RaycastHit2D hit = Physics2D.Raycast(ray.origin, ray.direction);

        if (hit)
        {
            if (Vector2.Distance(emptySpace.position, hit.transform.position) < 2)
            {
                Vector2 lastEmptySpacePosition = emptySpace.position;
                TileScript thisTile = hit.transform.GetComponent<TileScript>();
                emptySpace.position = thisTile.targetPosition;
                thisTile.targetPosition = lastEmptySpacePosition;

                int tileIndex = findIndex(thisTile);
                tiles[emptySpaceIndex] = tiles[tileIndex];

                tiles[tileIndex] = null;
                emptySpaceIndex = tileIndex;
            }
        }
    }
```

Figure 5.71: Scripts for switch tiles position

When Player clicks the tile, it will move into the empty space.



```
    if (!_isFinished)
    {

        int correctTiles = 0;
        foreach (var a in tiles)
        {
            if (a != null)
            {
                if (a.inRightPlace)
                {
                    correctTiles++;
                }
            }
        }

        if (correctTiles == tiles.Length - 1)
        {
            _isFinished = true;
            endPanel.SetActive(true);
            var a = GetComponent<TimerScript>();
            a.StopTimer();
            int score = (a.minutes * 60) + a.seconds;
            GameObject.Find("PlayFabManager").GetComponent<PlayFabManager15Puzzle>().SendLeaderboard(score);
            GameObject.Find("PlayFabManager").GetComponent<PlayFabManager15Puzzle>().SaveScore("15Puzzle", score);
            endPanelTimeText.text = (a.minutes < 10 ? "0" : "") + a.minutes + ":" + (a.seconds < 10 ? "0" : "") + a.seconds;
        }
    }
}
```

Figure 5.72: Scripts for check game won

If all of the tiles are in their correct positions, the game will end, and the time will be recorded.

5.5 Concluding remarks

The project involves a number of software and technology platforms. Adobe Illustrator, Unity3D, PlayFab, and Visual Studio 2019 are the software used in this serious game. Adobe Illustrator is used as the game's graphical sprites design platform. During the development phase, Unity3D is the primary software for organising and testing game content. PlayFabAPI connects Unity3D to PlayFab, and game scripts are edited in Visual Studio 2019. Login, four game categories, game controls, sending and retrieving player data, a community leaderboard, and a cognitive score will be included in the serious game modules.

Chapter 6

System Evaluation and Discussion

6.1 System Testing and Performance Metrics

The serious game for dementia prevention will be tested using black box testing approach as unit testing. Integration testing will be done to test the flow and connectivity of the game scenes and PlayFab.

6.1.1 Unit Testing

Login/Register

Testing Component	**Description**
Login/Register textbox	Test the textbox for entering email and password.
Login/Register button	Test the button if it is working fine

Table 6.1: Login/Register unit testing description

Main Menu

Testing component	**Description**
Start button	Test the button if it is working fine
Options button	Test the button if it is working fine
Cognitive score button	Test the button if it is working fine
Exit button	Test the button if it is working fine

Table 6.2: Main menu unit testing description

Game Selection

Testing component	Description
Speed game button	Test the button if it is working fine
Attention game button	Test the button if it is working fine
Memory game button	Test the button if it is working fine
Problem Solving game button	Test the button if it is working fine

Table 6.3: Game selection unit testing description

Games (Speed, Attention, Memory, and Problem Solving)

Testing component	Description
Game controls	Test the character, game object response to user input
Game object interaction	Test the game object colliders/triggers
Score/Timer controls	Test the score/timer
Tutorial	Test the game tutorial
Game Over	Test if game over panel will active when player lose the game
Pause	Test if pause panel will active when player pause the game

Table 6.4: Games unit testing description

Options

Testing component	Description
Screen Resolution	Test if the game will change screen resolution
Full Screen	Test if the game will enter/exit full screen
Volume controls	Test if the game volume will change

Table 6.5: Options unit testing description

Cognitive Score

Testing component	Description
Cognitive Score	Test if the cognitive score is calculated correctly
Refresh button	Test if the button is working fine

Table 6.6: Cognitive unit testing description

6.1.2 Integration Testing

Login/Register

Integration units	Description
Login/Register – PlayFab	Test if player credentials can be sent to PlayFab for login and register
Login – Main Menu	Test if main menu scene can be redirected after login

Table 6.7: Login/Register integration testing description

Main Menu

Integration units	Description
Main menu – Start	Test if game selection scene will be redirected
Main menu – Options	Test if options scene will be redirected
Main menu – Cognitive score	Test if cognitive score scene will be redirected
Main menu – Exit	Test if the game will exit

Table 6.8: Main menu integration testing description

Game Selection

Integration units	**Description**
Game Selection – Speed game	Test if Catch falling object scene will be redirected
Game Selection – Attention game	Test if Box Tower scene will be redirected
Game Selection – Memory game	Test if Matching Pair scene will be redirected
Game Selection – Problem Solving game	Test if 15Puzzle scene will be redirected

Table 6.9: Game selection integration testing description

Games (Speed, Attention, Memory, and Problem Solving)

Integration units	**Description**
Game – PlayFab (Send Player Data)	Test if score can be sent to PlayFab
Game – PlayFab (Send Leaderboard)	Test if score can be sent to PlayFab
Game – PlayFab (Get Leaderboard)	Test if Leaderboard can be retrieved from PlayFab
Game – Main Menu	Test if main menu scene can be redirected

Table 6.10: Games integration testing description

Cognitive Score

Integration units	**Description**
Cognitive Score – PlayFab	Test if the player data can be retrieved from PlayFab

Table 6.11: Cognitive score integration testing description

6.2 Testing Setup and Result

6.2.1 Unit Testing

Login/Register

Testing Component	Testing Input	Expected Output	Final Result
Login/Register textbox	Email: abc123 Password: abc123	Invalid input message	Invalid input message displayed
	Email: abc123@gmail.com Password:12	Invalid input message	Invalid input message displayed
	Email: abc123@gmail.com Password: abc123	Register/Login the user	System successfully register/login the user
Login/Register button	Click on the button	Console log message appear in the console	Console log message successfully appear in the console

Table 6.12: Login/Register unit testing test case and validation

Main Menu

Testing component	**Testing Input**	**Expected Output**	**Final Result**
Start button	Click on the button	Console log message appear in the console	Console log message successfully appear in the console
Options button	Click on the button	Console log message appear in the console	Console log message successfully appear in the console
Cognitive score button	Click on the button	Console log message appear in the console	Console log message successfully appear in the console
Exit button	Click on the button	Console log message appear in the console	Console log message successfully appear in the console

Table 6.13: Main menu unit testing test case and validation

Game Selection

Testing component	**Testing Input**	**Expected Output**	**Final Result**
Speed game button	Click on the button	Console log message appear in the console	Console log message successfully appear in the console
Attention game button	Click on the button	Console log message appear in the console	Console log message successfully appear in the console
Memory game button	Click on the button	Console log message appear in the console	Console log message successfully appear in the console
Problem Solving game button	Click on the button	Console log message appear in the console	Console log message successfully appear in the console

Table 6.14: Game selection unit testing test case and validation

Speed Game

Testing component	Testing Input	Expected Output	Final Result
Character controls	Control character using left/right key	Character move to left when left key is pressed; Character move to right when right key is pressed	Character move to left and right accordingly
Game object interaction	Control character to collect gems	Score increase by 1	Score update successfully
	Control character to avoid gems	Lives decrease by 1	Lives update successfully
	Control character to avoid bombs	Nothing changed	Nothing changed
	Control character to collect bombs	Game over panel appear	Game over panel appear
Score controls	Control character to collect gems	Score increase by 1	Score update successfully
	Game start/restart	Score reset to 0	Score start at 0
Tutorial	Click on the buttons on each tutorial screen	Tutorial will go forward with next button and backward with previous button	Tutorial go forward with next button and backward with previous button
Game Over	Control character to avoid 3 gems	Game over panel with final score, leaderboard button, restart button, main menu appears	Game over panel appear

	Control character to collect bombs	Game over panel with final score, leaderboard button, restart button, main menu appears	Game over panel appear
Pause	Press 'Esc' key	Pause panel with restart button, main menu button, quit button appears	Pause panel appear
	Press Pause button	Pause panel with restart button, main menu button, quit button appears	Pause panel appear

Table 6.15: Speed Game unit testing test case and validation

Attention Game

Testing component	**Testing Input**	**Expected Output**	**Final Result**
Box controls	Start game	Box moves right and left	Box moves right and left
	Press mouse key (test box drop)	Box drop	Box drop
	Press mouse key (test box land on box)	Box spawn and score update	Box spawn and score update
	Press mouse key (test box do not land on box)	Game over panel appear	Game over panel appears
Game object interaction	Press mouse key (test box land on box)	Box land on top of box and score updates	Box land on top of box and score updates
	Press mouse key (test box do not land on box)	Game over panel appears	Game over panel appears

Score controls	Press mouse key (test box land on box)	Score update by 1	Score successfully update by 1
Tutorial	Click on the buttons on each tutorial screen	Tutorial will go forward with next button and backward with previous button	Tutorial go forward with next button and backward with previous button
Game Over	Press mouse key (test box do not land on box)	Game over panel with final score, leaderboard button, restart button, main menu appears	Game over panel appear
Pause	Press 'Esc' key	Pause panel with restart button, main menu button, quit button appears	Pause panel appear
	Press Pause button	Pause panel with restart button, main menu button, quit button appears	Pause panel appear

Table 6.16: Attention game unit testing test case and validation

Memory Game

Testing component	**Testing Input**	**Expected Output**	**Final Result**
Game controls	Choose on one card	Card folds open	Card chosen folds open
	Choose on two cards (same pair)	Two cards fold open	Two cards chosen fold open
	Choose on two cards (different pair)	Two cards fold	Two cards chosen fold

Timer controls	Start game	The timer starts at 60	The timer starts at 60
	Timer equals to 0	Game over panel appears	Game over panel appears
Tutorial	Click on the buttons on each tutorial screen	Tutorial will go forward with next button and backward with previous button	Tutorial go forward with next button and backward with previous button
Game Over	Find all the pairs / timer runs out	Game over panel with final score, leaderboard button, restart button, main menu appears	Game over panel appear
Pause	Press ‘Esc’ key	Pause panel with restart button, main menu button, quit button appears	Pause panel appear
	Press Pause button	Pause panel with restart button, main menu button, quit button appears	Pause panel appear

Table 6.17: Memory game unit testing test case and validation

Problem Solving Game

Testing component	**Testing Input**	**Expected Output**	**Final Result**
Tiles controls	Start game	Tiles shuffled with solvable solution and last tiles is empty	Tiles shuffled with solvable solution and last tiles is empty
	Press tile next to empty space	Tile move to empty space	Tile pressed move to empty space
	Tiles to correct position	Tiles turn green	Tiles turn green
	Tiles are all in the correct position	Game over panel appears	Game over panel appears
Timer controls	Start game	Timer starts at 00:00	Timer starts at 00:00
	Complete puzzle	Timer stops	Timer stops
Tutorial	Click on the buttons on each tutorial screen	Tutorial will go forward with next button and backward with previous button	Tutorial go forward with next button and backward with previous button
Game Over	Complete the puzzle	Game over panel with final score, leaderboard button, restart button, main menu appears	Game over panel appear
Pause	Press 'Esc' key	Pause panel with restart button, main menu button, quit button appears	Pause panel appear
	Press Pause button	Pause panel with restart button, main menu button, quit button appears	Pause panel appear

Table 6.18: Problem solving unit testing test case and validation

Options

Testing component	**Testing input**	**Expected output**	**Final Result**
Screen Resolution	Change the game resolution: 720 * 680	The game will change the resolution to 720 * 680	The game changes the resolution to 720 * 680
Full Screen	Uncheck the full screen checkbox	The game will exit full screen	The game exits full screen
	Check the full screen checkbox	The game will enter full screen	The game enters full screen
Volume controls	Change the game volume to lower	The game volume will decrease	The game volume decreases
	Change the game volume to higher	The game volume will increase	The game volume increases

Table 6.19: Options unit testing test case and validation

Cognitive Score

Testing component	**Testing input**	**Expected output**	**Final result**
Cognitive Score	Go to cognitive score scene	There are values for each category score and the overall cognitive score is the total of score	The values for each categories and overall cognitive score are valid
Refresh button	Click on the refresh button	Console log message appear in the console	Console log message successfully appear in the console

Table 6.20: Cognitive score unit testing test case and validation

6.2.2 Integration Testing

Login/Register

Integration units	Testing input	Expected output	Final result
Login/Register – PlayFab	Register using email: 123@gmail.com and password: 123abc in the login scene	The register email and password are updated in PlayFab	The register email and password are successfully updated in PlayFab
	Login using email: 123@gmail.com and password: 123abc in the login scene	The player information will appear in PlayFab recent login	The player information appears in PlayFab recent login
Login – Main Menu	Input valid email and password and login	Main menu scene will be redirected	Main menu scene redirected successfully

Table 6.21: Login/Register integration testing test case and validation

Main Menu

Integration units	Testing input	Expected output	Final result
Main menu – Start	Click the start button	Game selection scene will be redirected	Game selection scene redirected successfully
Main menu – Options	Click the options button	options scene will be redirected	options scene will be redirected
Main menu – Cognitive score	Click the cognitive score button	cognitive score scene will be redirected	cognitive score scene will be redirected
Main menu – Exit	Click the exit button	The game will be exit	The game exits

Table 6.22: Main menu integration testing test case and validation

Game Selection

Integration units	**Testing input**	**Expected output**	**Final result**
Game Selection – Speed game	Click the speed game button	speed game scene will be redirected	speed game scene redirected successfully
Game Selection – Attention game	Click the attention game button	attention game scene will be redirected	attention game will be redirected
Game Selection – Memory game	Click the memory game button	memory game scene will be redirected	memory game scene will be redirected
Game Selection – Problem Solving game	Click the problem-solving game button	problem solving game scene will be redirected	problem solving game scene will be redirected

Table 6.23: Game selection integration testing test case and validation

Games (Speed, Attention, Memory, and Problem Solving)

Integration units	**Testing input**	**Expected output**	**Final result**
Game – PlayFab (Send Player Data)	Finish game	Score will be updated in PlayFab player data	Score updated in PlayFab player data
Game – PlayFab (Send Leaderboard)	Finish game	Score will be updated in PlayFab Leaderboard	Score updated in PlayFab Leaderboard
Game – PlayFab (Get Leaderboard)	Click on leaderboard	Player place, name, and score will appear on leaderboard	Player place, name, and score appears on leaderboard

Game – Main Menu	Click on Main menu button	Game will exit and return to main menu	Game exit and return to main menu

Table 6.24: Games integration testing test case and validation

Cognitive Score

Integration units	Testing input	Expected output	Final result
Cognitive Score – PlayFab	Start game	The categories values are the same as stored in PlayFab	The categories values are the same as stored in PlayFab

Table 6.25: Cognitive score integration testing test case and validation

6.3 Project Challenges

This project encounters a number of project challenges. For starters, both projects 1 and 2 have a time limit of 14 weeks. It is difficult because I must manage my time in order to focus on both the project and other academic subjects. If time management is not effective, both the project and other academic subjects will suffer in terms of quality and productivity. As there will be a weekly meeting with my supervisor, I need to keep my project updated and show progress. The COVID-19 pandemic was another challenge I encountered while working on the project. Because of online meeting, it is difficult for me to express my concerns to my supervisor. As a result, I must spend the majority of my time searching for solutions via online sources such as YouTube or other related forums.

Finally, the serious game for dementia prevention is built on the foundation of several serious games that assess various cognitive functions. I have no medical background, so designing the scoring matrix for the game and cognitive score is difficult. This is a major challenge in the project because I need to think about the design and implementation of the serious game.

6.4 Objectives Evaluation

Objectives	Work Done	Evaluation
Develop a Malaysia themed serious game for dementia prevention.	Game objects are designed with Malaysia Themed including Malaysia nostalgic snacks, traditional foods, etc.	Objective achieved
Develop a scoring matrix to assess dementia.	Scoring matrix are developed with reference to both Mini Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA)	Objective achieved
Cost-free serious game for elderly to prevent dementia.	The game is free and easy to use	Objective achieved
Develop a simple serious game for dementia prevention that runs on computer.	The game is a desktop game and the user interface, text, and fonts design and simple.	Objective achieved
Develop cloud connected serious game	The game is connected to PlayFab	Objective achieved

Table 6.26: Objectives and evaluation

6.5 Concluding Remark

The game is tested using the black-box testing method. Testing including Unit testing and integration testing are carried out. All modules and interfaces have been tested and validated. The challenges faced during the project development are tight schedules, online meeting and unfamiliar with the project field which require extra effort in understanding the dementia disease. Upon the end of the project, all the project's objectives have been met and verified.

Chapter 7

Conclusion and Recommendation

7.1 Conclusion

In conclusion, ageing is a normal process in our life that can't be prevented in anyways. The risk of getting dementia will increase with ageing. Most dementia disease are not curable but preventable. Thus, we should give our best to reduce and prevent any risk of dementia disease. Next, there is still a little progress in researches on how dementia develops. It is hard to find a clinically proven solution in assessing dementia. Another problem is most serious game for dementia prevention are complex and need users to pay for expensive cost to play. Moreover, Malaysian perceive dementia as a normal process of ageing. They are keen to not seek for professional advice or do diagnosis when they grew old.

The project is motivated to develop a serious game for dementia prevention. The serious game will help the public to assess and prevent dementia. In addition, an efficient assessment test to assess dementia will be develop and included to help people to assess dementia. The system will be cost-free and everyone can play the serious game without worrying of paying for full version. Furthermore, the serious game UI are simple and to help elderly understand the system controls. The project will also be the first few Malaysia themed serious game. The serious game aimed to help Malaysian to be more exposed to dementia, educating and increase their awareness about dementia.

The proposed system will be a Malaysia themed serious game with Malaysia elements such as tradition food and festivals. The system will contain several games to assess dementia and being grouped into different categories such as “speed”, “memory”, “attention” and “problem solving”. Each groups aims to assess different cognitive functionalities based on their game characteristic. An overall cognitive score will be calculated from all the cognitive scores based on Montreal Cognitive Assessment (MoCA) and Mini-Mental State Examination (MMSE). The system will send the user’s scores to the cloud for storage. Player scores will also be updated to the PlayFab leaderboard.

REFERENCES

[1] "Fun and games," *Alzheimer's Society*, 01-Aug-2018. [Online]. Available: https://www.alzheimers.org.uk/dementia-together-magazine/dec-jan-2017-2018/fun-and-games. [Accessed: 17-Apr-2022].

[2] M. Tsolaki, S. Paraskevi, N. Degleris, and S. Karamavrou, "Attitudes and perceptions regarding alzheimer's disease in Greece," *American Journal of Alzheimer's Disease & Other Dementiasr*, vol. 24, no. 1, pp. 21–26, 2008.

[3] Gil L., Jonathan H., Andrew S., David A., Clive B., Sube B., Carol B., Alistair B., Jiska C, Vludia C, Sergi G. C, Amit D, Nick F., Laura G., Robert H., Helen C. K., Mike K., Eric B L, Adesola O, Vasiliki O, Karen R, Kenneth R, Elizabeht L. S, Quincy S, Lon S. S, Geir S, Linda T, Naaheed M, 2020. *Dementia prevention, intervention, and care: 2020 report of the Lancet Commission*, [online] Available at: <http://www.thelancet.com> [Accessed on 17th July 2021].

[4] "What is dementia? symptoms, types, and diagnosis," *National Institute on Aging*, 2017. [Online]. Available: https://www.nia.nih.gov/health/what-dementia-symptoms-types-and-diagnosis. [Accessed: 17-Apr-2022].

[5] "Can dementia be prevented?" *National Health Service UK*, 2021. [Online]. Available: https://www.nhs.uk/conditions/dementia/dementia-prevention/#:~:text=There's%20no%20certain%20way%20to,dementia%20when%20you're%20older. [Accessed: 17-Apr-2022].

[6] H. A. Karim, "The Elderly in Malaysia : Demographic Trend," *Med J Malaysia*, vol. 52, no. 3, pp. 206–212, 1997.

[7] "Dementia in the Asia Pacific Region," *Alzheimer's disease foundation*, pp. 42–43, 2014.

[8] Azlina W. N., Graeme H., S. Hassan A. A., (2017) *Dementia in Malaysia: Issues and Challenges, Asean Journal of Psychiatry*, 12(2011), pp. 95-101. Available : https://www.aseanjournalofpsychiatry.org/abstract/dementia-in-malaysia-issues-and-challenges-53454.html [Accessed 6th June 2021].

[9] “Mini-Mental State Exam (MMSE) Alzeimer’s / Dementia Test: Administration, Accuracy and Scoring.” *Dementia Care Central*, 2020. [Online] Available: https://www.dementiacarecentral.com/mini-mental-state-exam/ [Accessed 2nd July 2021].

[10] T. A. Schweizer, T. Al-Khindi, and R. L. Macdonald, “Mini-mental state examination versus Montreal cognitive assessment: Rapid assessment tools for cognitive and functional outcome after aneurysmal subarachnoid hemorrhage,” *Journal of the Neurological Sciences*, vol. 316, no. 1-2, pp. 137–140, 2012.

[11] “Montreal Cognitive Assessment Test (MoCA) for Dementia &Alzheimer’s” *Dementia Care Central*, 2020. [Online] Available: https://www.dementiacarecentral.com/montreal-cognitive-assessment-test/ [Accessed 5th June 2021].

[12] K. Kang, E.-J. Choi, and Y.-S. Lee, “Proposal of a serious game to help prevent dementia,” *Lecture Notes in Computer Science*, pp. 415–424, 2016.

[13] “What are serious games?” *Grendel Games*, 2003. [Online] Available: https://grendelgames.com/what-are-serious-games/ [Assessed 10 June 2021].

[14] F. Laamarti, M. Eid, and A. El Saddik, “An overview of serious games,” *International Journal of Computer Games Technology*, vol. 2014, pp. 1–15, 2014.

[15] S. McCallum and C. Boletsis, “Dementia games: A literature review of dementia-related serious games,” *Serious Games Development and Applications*, pp. 15–27, 2013.

[16] T. Tong, J. H. Chan, and M. Chignell, “Serious games for dementia,” *Proceedings of the 26th International Conference on World Wide Web Companion - WWW '17 Companion*, 2017.

[17] “MindMate” *MindMate*, 2021. [Online] Available: https://web.mindmate-app.com/. [Accessed 3th June 2021].

[18] “CogniFit” *CogniFit*, 2021. [Online] Available: https://www.cognifit.com/ [Accessed 3th April 2021].

[19] “Lumosity” *Lumosity, 2021*. [Online] Available: https://www.lumosity.com/en/ [Accessed 3th June 2021]

[20] AwesomeTuts. “Unity Mobile Game Development For Beginners | Create A Simple 2D Game,” *Youtube,* 10-May-2019. Available:https://www.youtube.com/watch?v=4QP0ZTPUaI4 [Accessed : Mar 20,2022]

[21] AwesomeTuts. “Unity Game Development - Memory Game,” *Youtube,* 30-Aug-2015. Available: https://www.youtube.com/watch?v=qaCjBh7bWz0&list=PLZhNP5qJ2IA2DA4bzDyxFMs8yogVQSrjW&index=1 [Accessed: Jan 10, 2022].

[22] Coco Code. “Easy multiplayer in Unity Setup - How to use PlayFab in Unity tutorial (#1),” *Youtube,* 17-Sep-2020. Available: https://www.youtube.com/watch?v=DQWYMfZyMNU&list=PL1aAeF6bPTB4oP-Tejys3n8P8iXlj7uj- [Accessed: Jan 10, 2022].

[23] D. L. Segal, “Diagnostic and statistical manual of mental disorders,” *The Corsini Encyclopedia of Psychology*, 2010.

[24] M. D. Andrew Rosenzweig, “Montreal Cognitive Assessment (MOCA) test for Dementia,” *Verywell Health*, 29-Jan-2022. [Online]. Available: https://www.verywellhealth.com/alzheimers-and-montreal-cognitive-assessment-moca-98617. [Accessed: 17-Apr-2022].

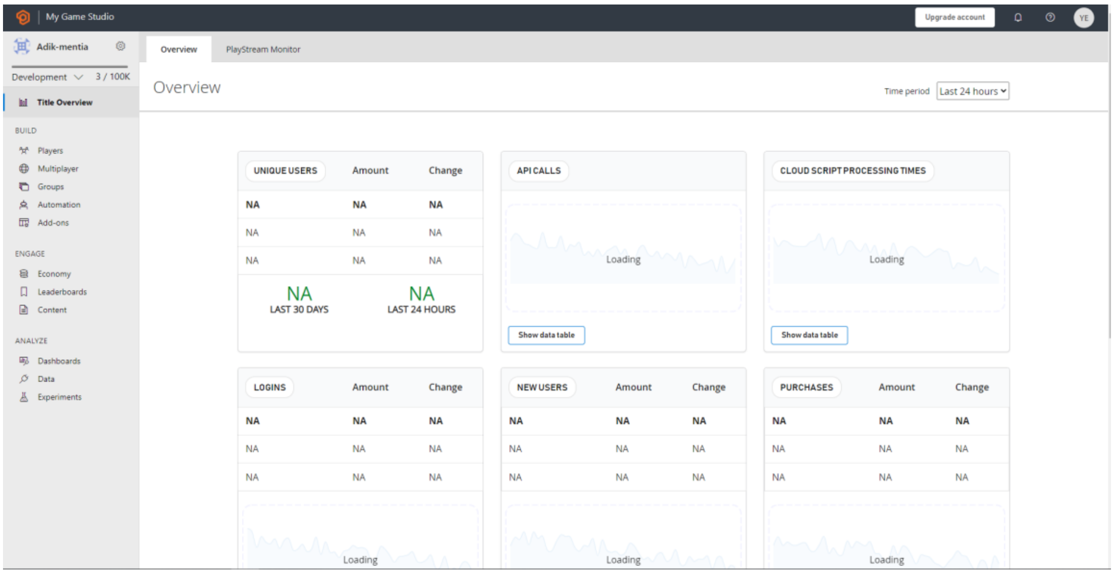
[25] R. Mat and H. M. Taha, “Socio-economic Characteristics of the Elderly in Malaysia,” *21st Population Census Conference*, 2003.

[26] S. Kazmi, H. Ugail, V. Lesk, and I. Palmer, “Interactive digital serious games for the assessment, rehabilitation, and prediction of dementia,” *International Journal of Computer Games Technology*, vol. 2014, pp. 1–11, 2014.

[27] Tidominer. “How to create Sliding Puzzle in Unity - Part 1 (Setting up and Basic movement),” *Youtube,* 13-Nov-2020. Available: https://www.youtube.com/watch?v=rJFprTG3wE0&t=5s [Accessed: Feb 10, 2022].

APPENDIX

A.1 PlayFab Interface



UNIQUE USERS	Amount	Change
NA	NA	NA
NA	NA	NA
NA	NA	NA

NA LAST 30 DAYS

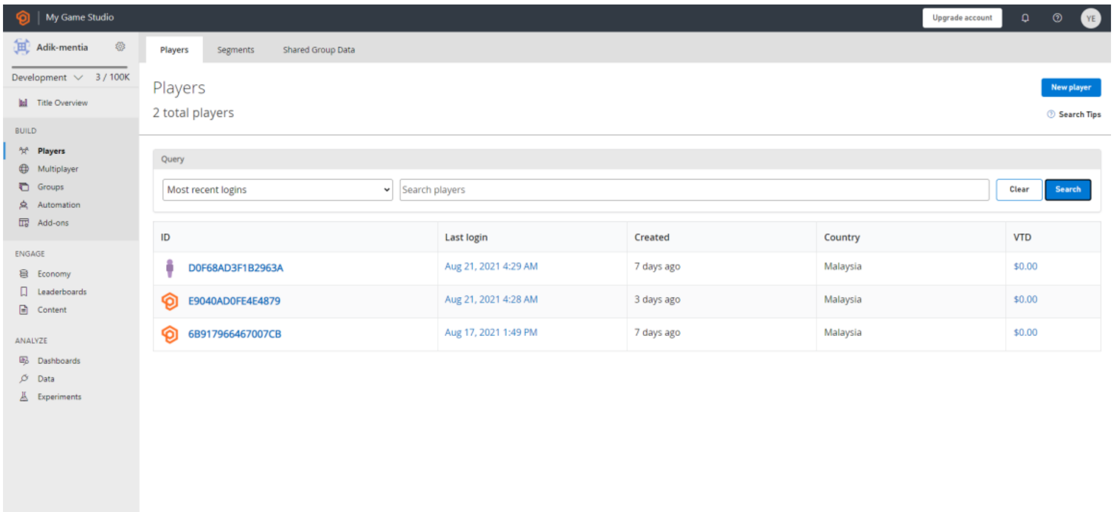
NA LAST 24 HOURS

LOGINS	Amount	Change
NA	NA	NA
NA	NA	NA
NA	NA	NA

NEW USERS	Amount	Change
NA	NA	NA
NA	NA	NA
NA	NA	NA

PURCHASES	Amount	Change
NA	NA	NA
NA	NA	NA
NA	NA	NA

Figure A-1: PlayFab Overview



Players

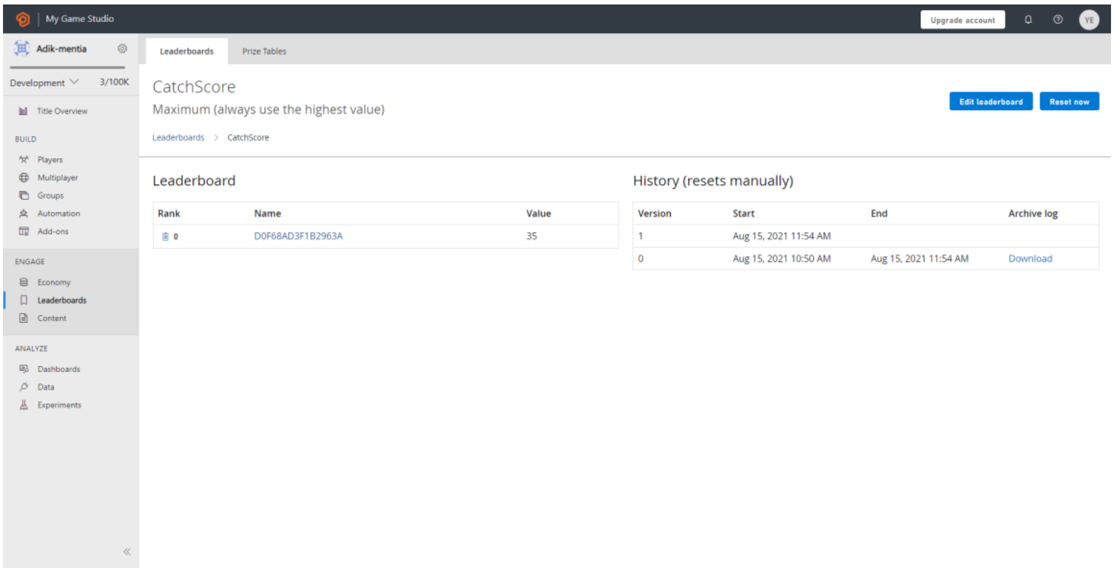
2 total players

Most recent logins

Search players

ID	Last login	Created	Country	VTD
D0F68AD3F1B2963A	Aug 21, 2021 4:29 AM	7 days ago	Malaysia	$0.00
E9040AD0FE4E4879	Aug 21, 2021 4:28 AM	3 days ago	Malaysia	$0.00
6B917966467007CB	Aug 17, 2021 1:49 PM	7 days ago	Malaysia	$0.00

Figure A-2: PlayFab Players



CatchScore

Maximum (always use the highest value)

Leaderboard

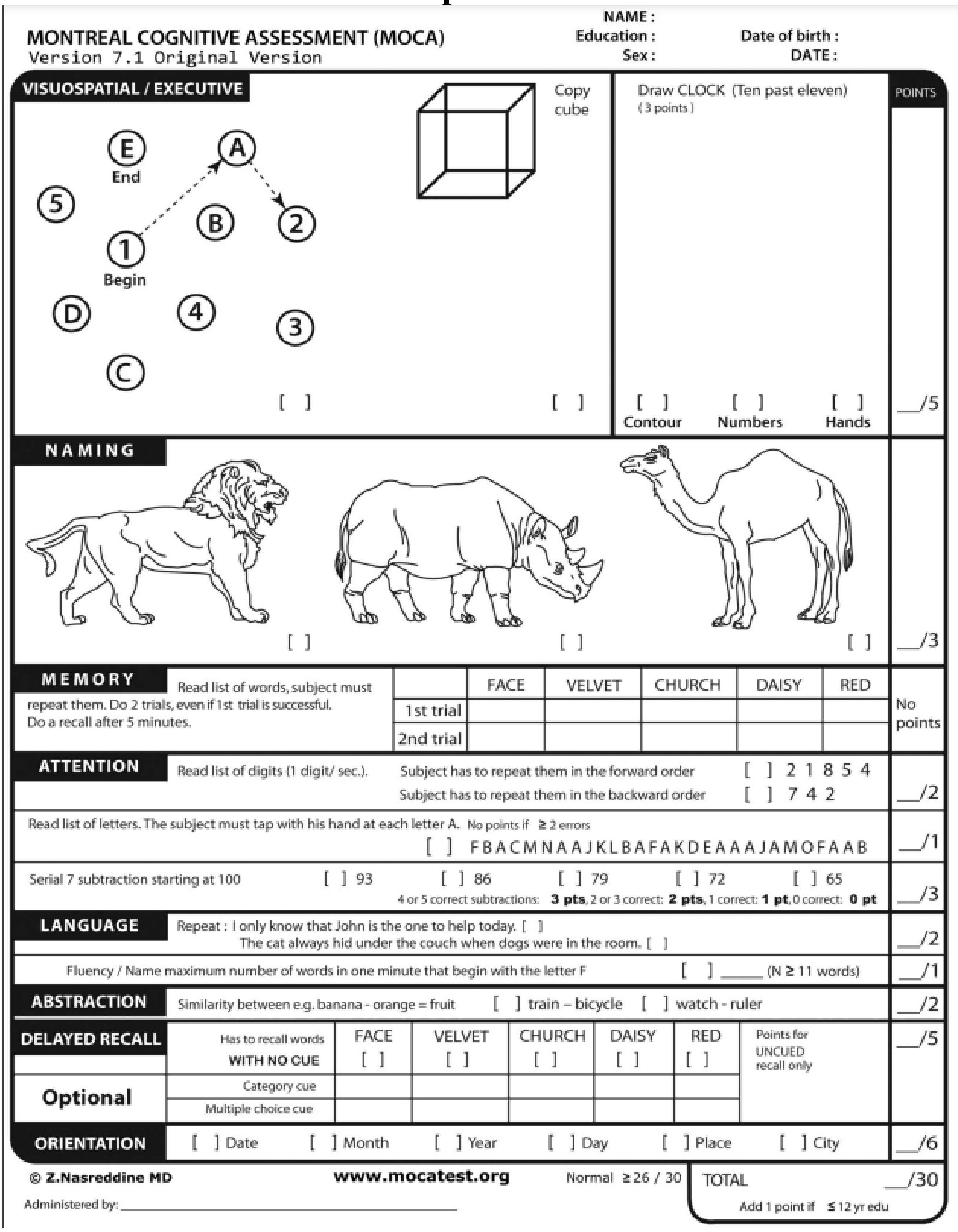
Rank	Name	Value
0	D0F68AD3F1B2963A	35

History (resets manually)

Version	Start	End	Archive log
1	Aug 15, 2021 11:54 AM		
0	Aug 15, 2021 10:50 AM	Aug 15, 2021 11:54 AM	Download

Figure A-3: PlayFab Leaderboard

A.2 Dementia Assessment Sample


E
End
A
5
B
2
1
Begin
D
4
3
C

NAME :
Education : Date of birth :
Sex : DATE :

MONTREAL COGNITIVE ASSESSMENT (MOCA)
Version 7.1 Original Version

VISUOSPATIAL / EXECUTIVE

[ ]

Copy cube [ ]

Draw CLOCK (Ten past eleven) (3 points)

[ ] Contour [ ] Numbers [ ] Hands

POINTS __/5

NAMING

[ ] [ ] [ ] __/3

MEMORY Read list of words, subject must repeat them. Do 2 trials, even if 1st trial is successful. Do a recall after 5 minutes.

	FACE	VELVET	CHURCH	DAISY	RED
1st trial					
2nd trial					

No points

ATTENTION Read list of digits (1 digit/ sec.). Subject has to repeat them in the forward order [ ] 2 1 8 5 4
Subject has to repeat them in the backward order [ ] 7 4 2 __/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors
[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B __/1

Serial 7 subtraction starting at 100 [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65
4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt** __/3

LANGUAGE Repeat : I only know that John is the one to help today. [ ]
The cat always hid under the couch when dogs were in the room. [ ] __/2

Fluency / Name maximum number of words in one minute that begin with the letter F [ ] _____ (N ≥ 11 words) __/1

ABSTRACTION Similarity between e.g. banana - orange = fruit [ ] train – bicycle [ ] watch - ruler __/2

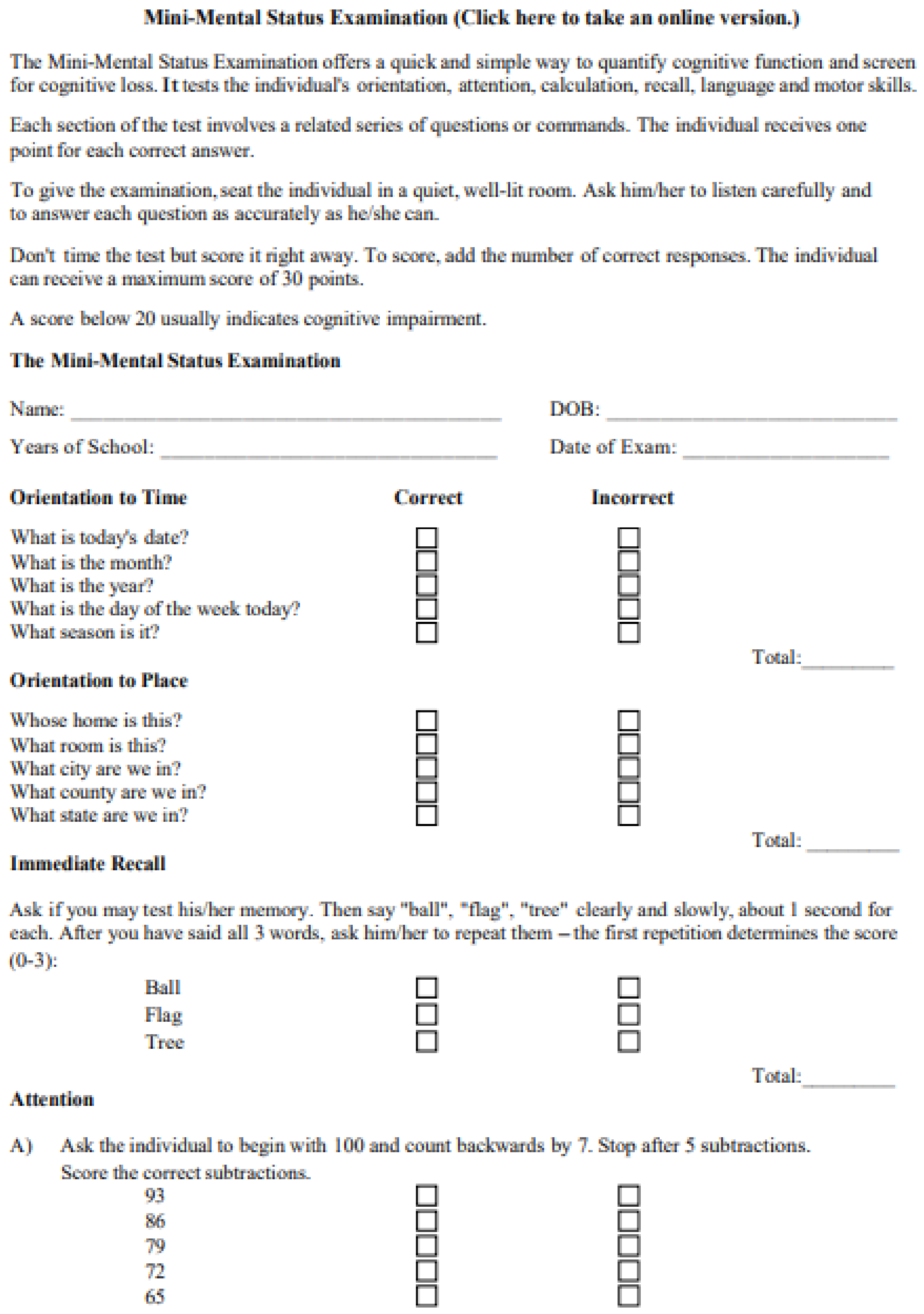
DELAYED RECALL	Has to recall words **WITH NO CUE**	FACE [ ]	VELVET [ ]	CHURCH [ ]	DAISY [ ]	RED [ ]	Points for UNCUED recall only	__/5
Optional	Category cue							
	Multiple choice cue							

ORIENTATION [ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City __/6

© Z.Nasreddine MD www.mocatest.org Normal ≥26 / 30 TOTAL __/30
Add 1 point if ≤ 12 yr edu

Administered by: ______________________________

Figure A-4: Montreal Cognitive Assessment (MoCA)



Mini-Mental Status Examination (Click here to take an online version.)

The Mini-Mental Status Examination offers a quick and simple way to quantify cognitive function and screen for cognitive loss. It tests the individual's orientation, attention, calculation, recall, language and motor skills.

Each section of the test involves a related series of questions or commands. The individual receives one point for each correct answer.

To give the examination, seat the individual in a quiet, well-lit room. Ask him/her to listen carefully and to answer each question as accurately as he/she can.

Don't time the test but score it right away. To score, add the number of correct responses. The individual can receive a maximum score of 30 points.

A score below 20 usually indicates cognitive impairment.

The Mini-Mental Status Examination

Name: ______________________________ DOB: ____________________

Years of School: _______________________ Date of Exam: ______________

Orientation to Time	Correct	Incorrect
What is today's date?	□	□
What is the month?	□	□
What is the year?	□	□
What is the day of the week today?	□	□
What season is it?	□	□

Total:________

Orientation to Place		
Whose home is this?	□	□
What room is this?	□	□
What city are we in?	□	□
What county are we in?	□	□
What state are we in?	□	□

Total: ________

Immediate Recall

Ask if you may test his/her memory. Then say "ball", "flag", "tree" clearly and slowly, about 1 second for each. After you have said all 3 words, ask him/her to repeat them – the first repetition determines the score (0-3):

Ball	□	□
Flag	□	□
Tree	□	□

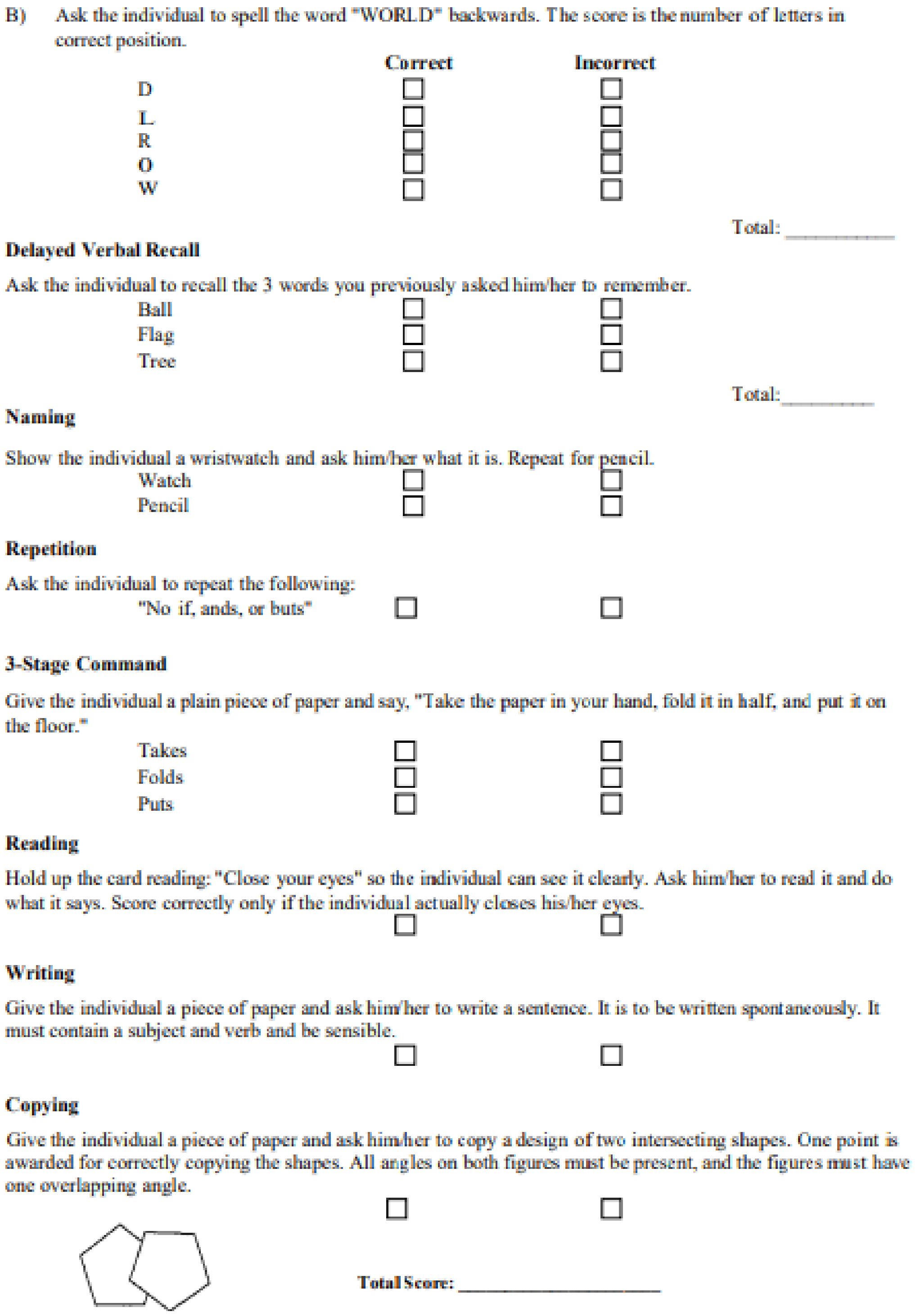
Total:________

Attention

A) Ask the individual to begin with 100 and count backwards by 7. Stop after 5 subtractions. Score the correct subtractions.

93	□	□
86	□	□
79	□	□
72	□	□
65	□	□

Figure A-5: Mini Mental State Examination (MMSE)



B) Ask the individual to spell the word "WORLD" backwards. The score is the number of letters in correct position.

	Correct	Incorrect
D	□	□
L	□	□
R	□	□
O	□	□
W	□	□

Total: ___________

Delayed Verbal Recall

Ask the individual to recall the 3 words you previously asked him/her to remember.

Ball	□	□
Flag	□	□
Tree	□	□

Total:_________

Naming

Show the individual a wristwatch and ask him/her what it is. Repeat for pencil.

Watch	□	□
Pencil	□	□

Repetition

Ask the individual to repeat the following:

"No if, ands, or buts"	□	□

3-Stage Command

Give the individual a plain piece of paper and say, "Take the paper in your hand, fold it in half, and put it on the floor."

Takes	□	□
Folds	□	□
Puts	□	□

Reading

Hold up the card reading: "Close your eyes" so the individual can see it clearly. Ask him/her to read it and do what it says. Score correctly only if the individual actually closes his/her eyes.

□ □

Writing

Give the individual a piece of paper and ask him/her to write a sentence. It is to be written spontaneously. It must contain a subject and verb and be sensible.

□ □

Copying

Give the individual a piece of paper and ask him/her to copy a design of two intersecting shapes. One point is awarded for correctly copying the shapes. All angles on both figures must be present, and the figures must have one overlapping angle.

□ □

Total Score: ____________________

Figure A-6: Mini Mental State Examination (MMSE)

A3. System Acceptance Test Survey

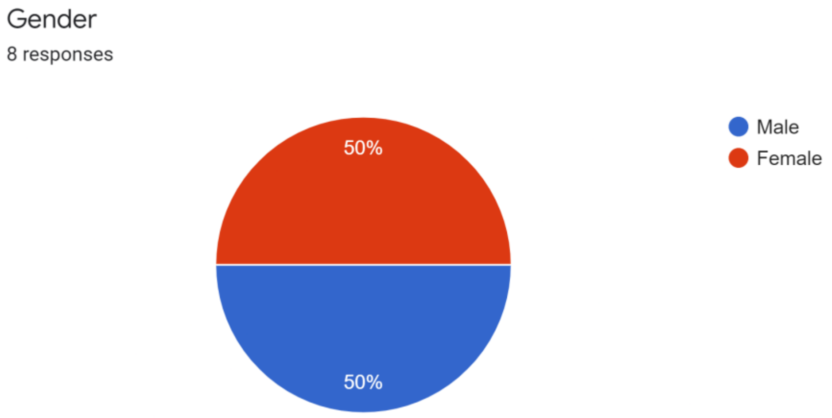


Figure A-7: Survey Gender Pie chart

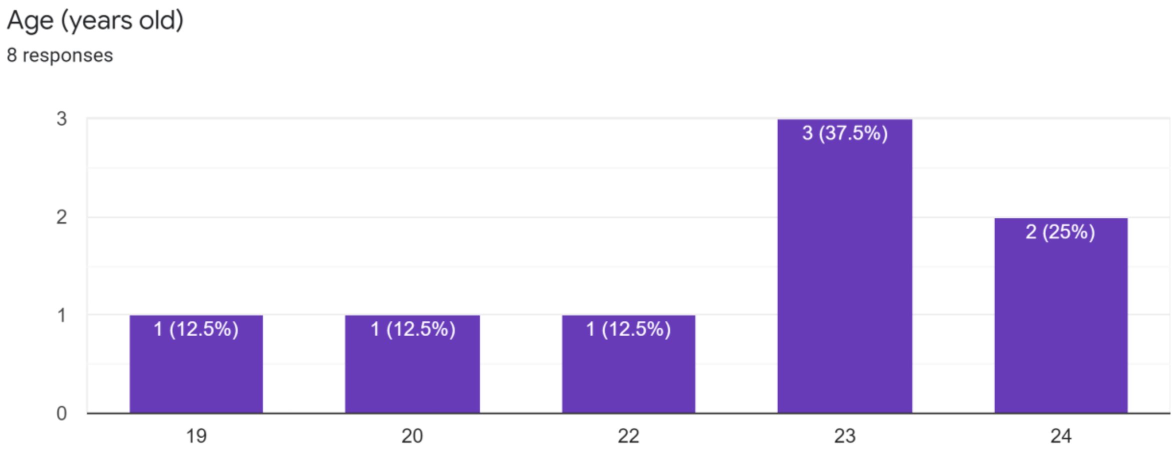
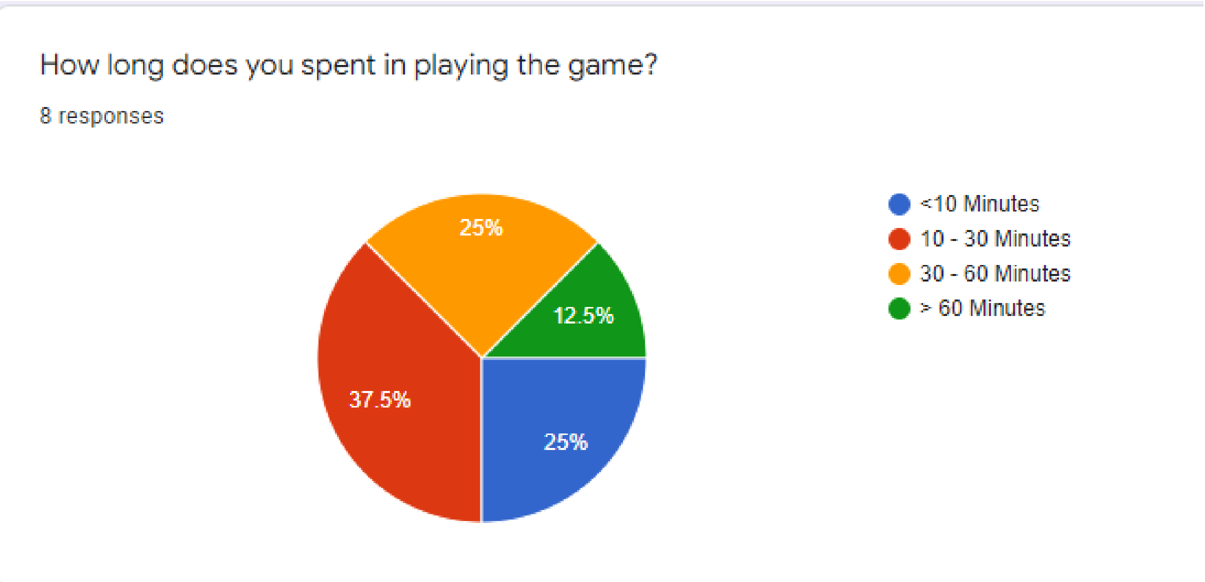


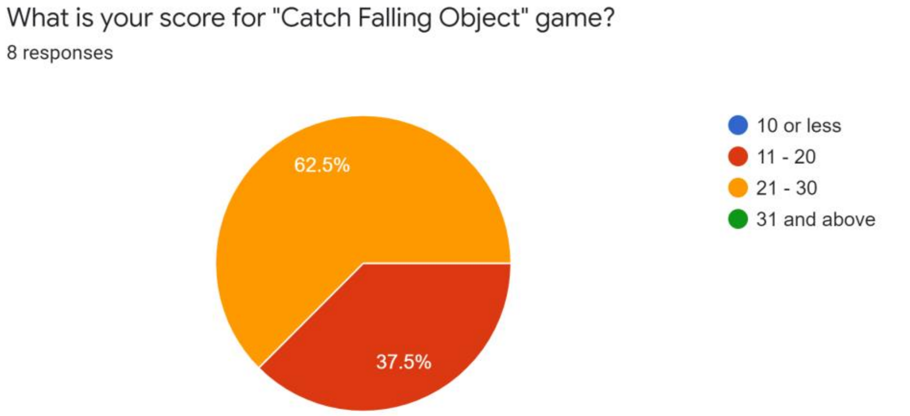
Figure A-8: Survey Age Bar chart



How long does you spent in playing the game?

8 responses

Figure A-9: Survey Time Spent Pie chart



What is your score for "Catch Falling Object" game?

8 responses

Figure A-10: Survey Catch Falling Object Pie chart

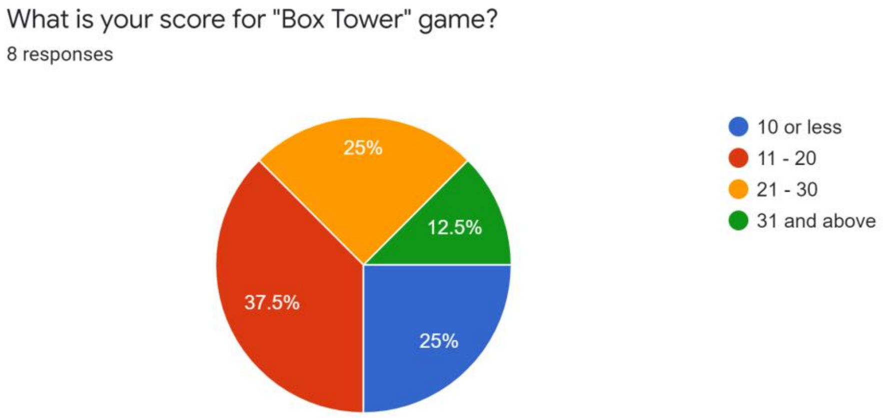


Figure A-11: Survey Box Tower Pie chart

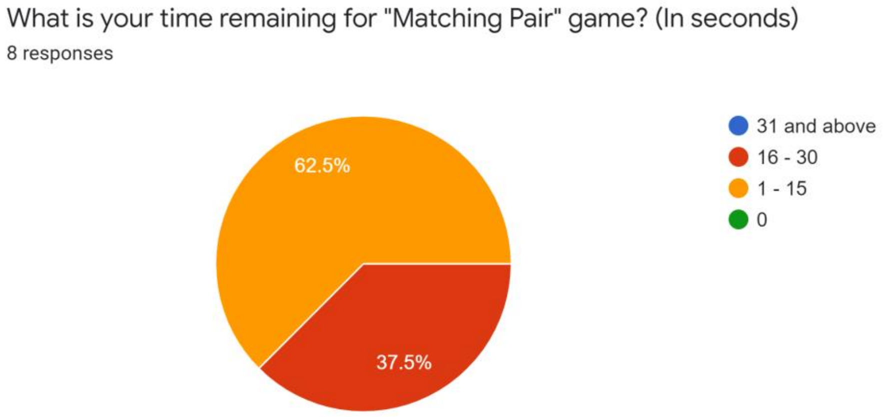


Figure A-12: Survey Gender Pie chart

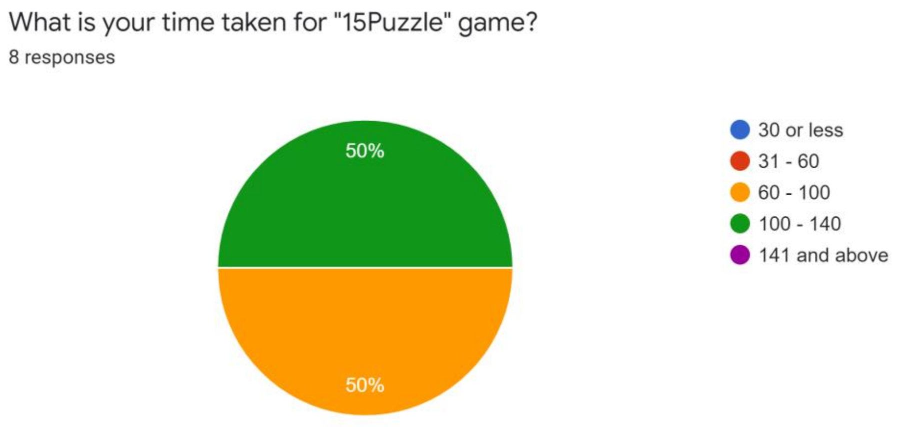


Figure A-13: Survey 15Puzzle Pie chart

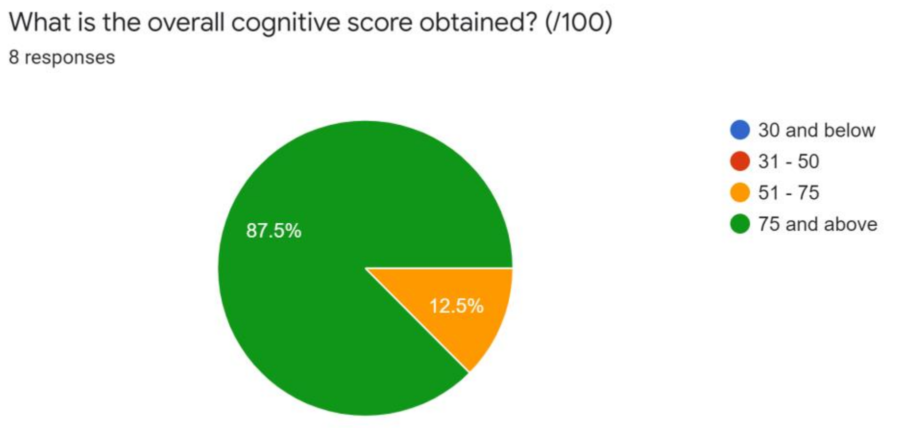
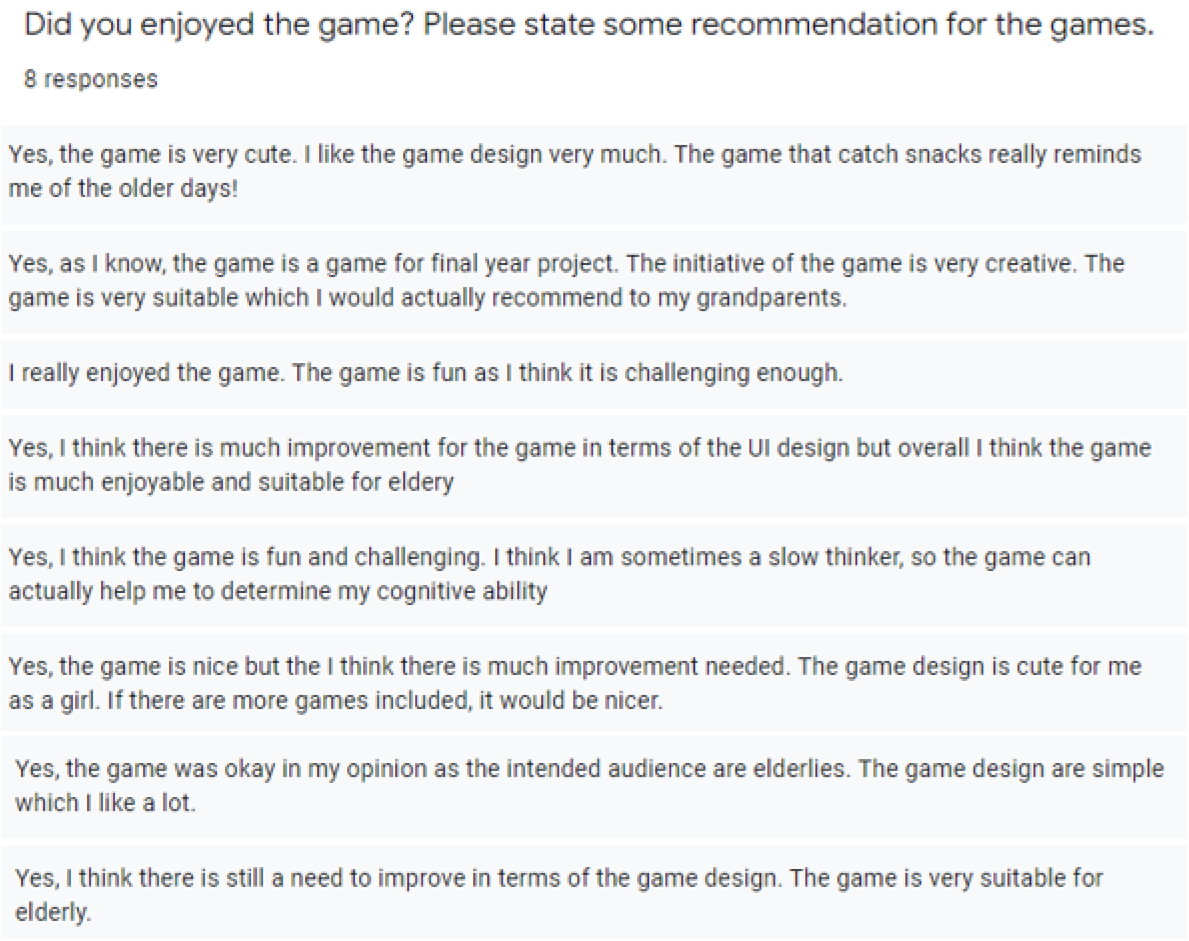


Figure A-14: Survey Cognitive Score Pie chart



Did you enjoyed the game? Please state some recommendation for the games.

8 responses

Yes, the game is very cute. I like the game design very much. The game that catch snacks really reminds me of the older days!

Yes, as I know, the game is a game for final year project. The initiative of the game is very creative. The game is very suitable which I would actually recommend to my grandparents.

I really enjoyed the game. The game is fun as I think it is challenging enough.

Yes, I think there is much improvement for the game in terms of the UI design but overall I think the game is much enjoyable and suitable for eldery

Yes, I think the game is fun and challenging. I think I am sometimes a slow thinker, so the game can actually help me to determine my cognitive ability

Yes, the game is nice but the I think there is much improvement needed. The game design is cute for me as a girl. If there are more games included, it would be nicer.

Yes, the game was okay in my opinion as the intended audience are elderlies. The game design are simple which I like a lot.

Yes, I think there is still a need to improve in terms of the game design. The game is very suitable for elderly.

Figure A-15: Survey Recommendation for the system

A4. FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: 3,3	**Study week no.: 2**
Student Name & ID: Yew Wei Hong 18ACB04417	
Supervisor: Ts. Saw Seow Hui	
Project Title: An Interactive Serious Game for Dementia Prevention	

1. WORK DONE

Revise the previous work done and plan on project items and tasks left

2. WORK TO BE DONE

Start with the development after revising

3. PROBLEMS ENCOUNTERED

Need to recall what had been done in FYP1

4. SELF EVALUATION OF THE PROGRESS

So far so good

Saw

Supervisor's signature

Student's signature

Trimester, Year: 3,3	**Study week no.: 3**
Student Name & ID: Yew Wei Hong 18ACB04417	
Supervisor: Ts. Saw Seow Hui	
Project Title: An Interactive Serious Game for Dementia Prevention	

1. WORK DONE

Start with the second game which is matching pair

2. WORK TO BE DONE

Design of matching pair graphics

3. PROBLEMS ENCOUNTERED

So far so good

4. SELF EVALUATION OF THE PROGRESS

So far so good

Saw

Supervisor's signature

Student's signature

Trimester, Year: 3,3	**Study week no.: 4**
Student Name & ID: Yew Wei Hong 18ACB04417	
Supervisor: Ts. Saw Seow Hui	
Project Title: An Interactive Serious Game for Dementia Prevention	

1. WORK DONE

Done matching pair game

2. WORK TO BE DONE

Start with the next game which is box tower next week

3. PROBLEMS ENCOUNTERED

So far so good

4. SELF EVALUATION OF THE PROGRESS

So far so good

Saw

Supervisor's signature

Student's signature

Trimester, Year: 3,3	**Study week no.: 5**
Student Name & ID: Yew Wei Hong 18ACB04417	
Supervisor: Ts. Saw Seow Hui	
Project Title: An Interactive Serious Game for Dementia Prevention	

1. WORK DONE

Started box tower graphics design

2. WORK TO BE DONE

Box tower game controls

3. PROBLEMS ENCOUNTERED

So far so good

4. SELF EVALUATION OF THE PROGRESS

So far so good

Saw

Supervisor's signature

Student's signature

Trimester, Year: 3,3	**Study week no.: 6**
Student Name & ID: Yew Wei Hong 18ACB04417	
Supervisor: Ts. Saw Seow Hui	
Project Title: An Interactive Serious Game for Dementia Prevention	

1. WORK DONE

Box Tower game control done

2. WORK TO BE DONE

Start with next game which is matching pair

3. PROBLEMS ENCOUNTERED

So far so good

4. SELF EVALUATION OF THE PROGRESS

So far so good

Saw

Supervisor's signature

y

Student's signature

Trimester, Year: 3,3	**Study week no.: 7**
Student Name & ID: Yew Wei Hong 18ACB04417	
Supervisor: Ts. Saw Seow Hui	
Project Title: An Interactive Serious Game for Dementia Prevention	

1. WORK DONE

Matching pair graphics done

2. WORK TO BE DONE

Complete matching pair game controls

3. PROBLEMS ENCOUNTERED

So far so good

4. SELF EVALUATION OF THE PROGRESS

So far so good

Saw

Supervisor's signature

Y

Student's signature

Trimester, Year: 3,3	**Study week no.: 8**
Student Name & ID: Yew Wei Hong 18ACB04417	
Supervisor: Ts. Saw Seow Hui	
Project Title: An Interactive Serious Game for Dementia Prevention	

1. WORK DONE

Matching pair game done

2. WORK TO BE DONE

Start with 15Puzzle game

3. PROBLEMS ENCOUNTERED

So far so good

4. SELF EVALUATION OF THE PROGRESS

So far so good

Supervisor's signature

Student's signature

Trimester, Year: 3,3	**Study week no.: 9**
Student Name & ID: Yew Wei Hong 18ACB04417	
Supervisor: Ts. Saw Seow Hui	
Project Title: An Interactive Serious Game for Dementia Prevention	

1. WORK DONE

Done with 15puzzle graphics

2. WORK TO BE DONE

Start with 15puzzle game controls

3. PROBLEMS ENCOUNTERED

So far so good

4. SELF EVALUATION OF THE PROGRESS

So far so good

Saw

Supervisor's signature

Student's signature

Trimester, Year: 3,3	**Study week no.: 10**
Student Name & ID: Yew Wei Hong 18ACB04417	
Supervisor: Ts. Saw Seow Hui	
Project Title: An Interactive Serious Game for Dementia Prevention	

1. WORK DONE

15Puzzle game controls done

2. WORK TO BE DONE

Start with game over, pause, tutorial for each game

3. PROBLEMS ENCOUNTERED

So far so good

4. SELF EVALUATION OF THE PROGRESS

So far so good

Saw

Supervisor's signature

Student's signature

Trimester, Year: 3,3	**Study week no.: 11**
Student Name & ID: Yew Wei Hong 18ACB04417	
Supervisor: Ts. Saw Seow Hui	
Project Title: An Interactive Serious Game for Dementia Prevention	

1. WORK DONE

Game over, pause, tutorial for each game completed partially

2. WORK TO BE DONE

Done with game over, pause and tutorial for each game

3. PROBLEMS ENCOUNTERED

So far so good

4. SELF EVALUATION OF THE PROGRESS

So far so good

Saw

Supervisor's signature

Y

Student's signature

Trimester, Year: 3,3	**Study week no.: 12**
Student Name & ID: Yew Wei Hong 18ACB04417	
Supervisor: Ts. Saw Seow Hui	
Project Title: An Interactive Serious Game for Dementia Prevention	

1. WORK DONE Done with game over, pause, tutorial for each game
2. WORK TO BE DONE Test the serious game and start with the report
3. PROBLEMS ENCOUNTERED So far so good
4. SELF EVALUATION OF THE PROGRESS FYP2 is almost done

Saw

Supervisor's signature

Student's signature

Trimester, Year: 3,3	**Study week no.: 13**
Student Name & ID: Yew Wei Hong 18ACB04417	
Supervisor: Ts. Saw Seow Hui	
Project Title: An Interactive Serious Game for Dementia Prevention	

1. WORK DONE

Tested the serious game and done with the report

2. WORK TO BE DONE

-

3. PROBLEMS ENCOUNTERED

So far so good

4. SELF EVALUATION OF THE PROGRESS

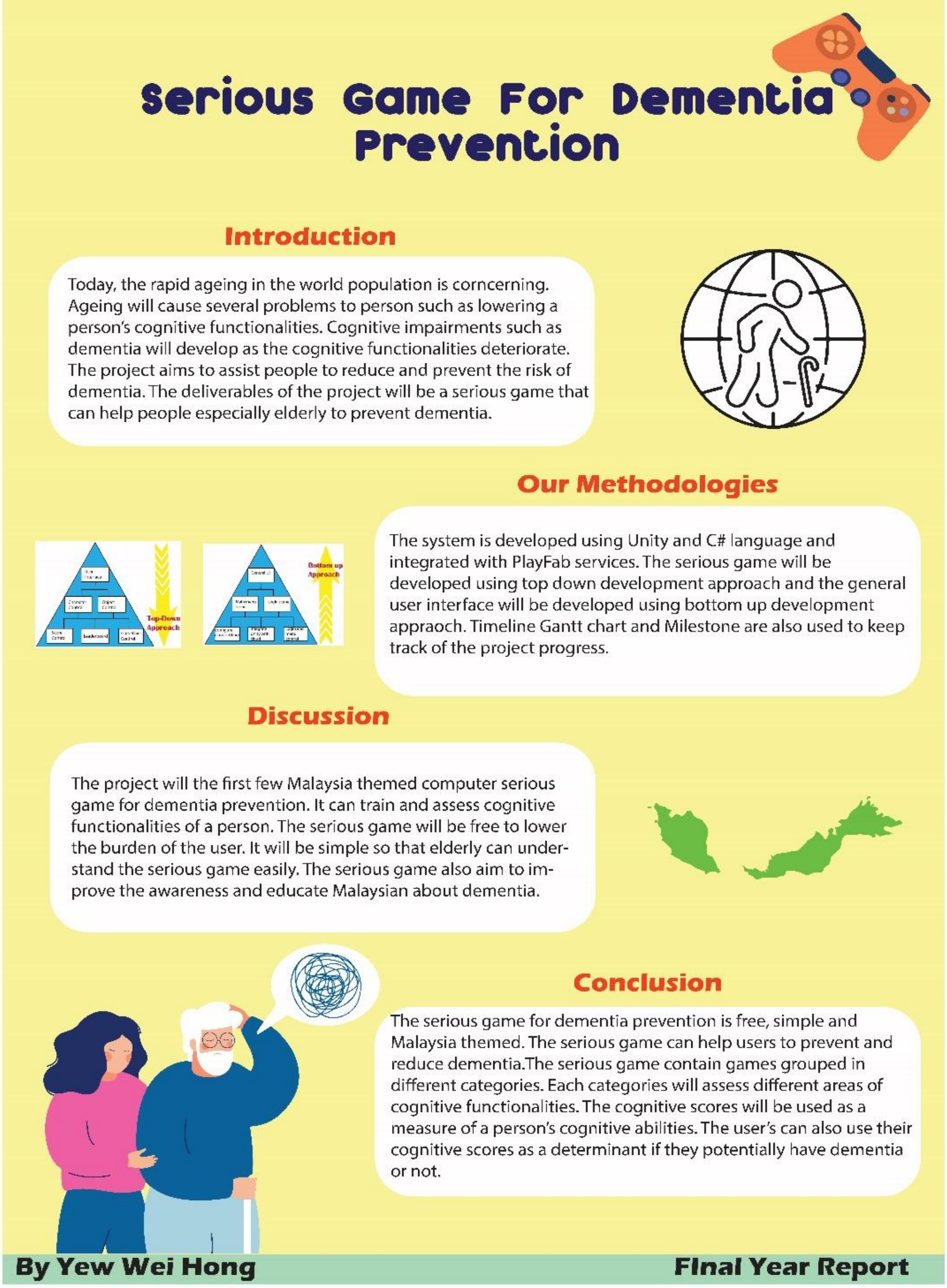
FYP2 progress can be completed

Saw

Supervisor's signature

Student's signature

A5. POSTER



Serious Game For Dementia Prevention

Introduction

Today, the rapid ageing in the world population is corncerning. Ageing will cause several problems to person such as lowering a person's cognitive functionalities. Cognitive impairments such as dementia will develop as the cognitive functionalities deteriorate. The project aims to assist people to reduce and prevent the risk of dementia. The deliverables of the project will be a serious game that can help people especially elderly to prevent dementia.

Our Methodologies

The system is developed using Unity and C# language and integrated with PlayFab services. The serious game will be developed using top down development approach and the general user interface will be developed using bottom up development appraoch. Timeline Gantt chart and Milestone are also used to keep track of the project progress.

Discussion

The project will the first few Malaysia themed computer serious game for dementia prevention. It can train and assess cognitive functionalities of a person. The serious game will be free to lower the burden of the user. It will be simple so that elderly can understand the serious game easily. The serious game also aim to improve the awareness and educate Malaysian about dementia.

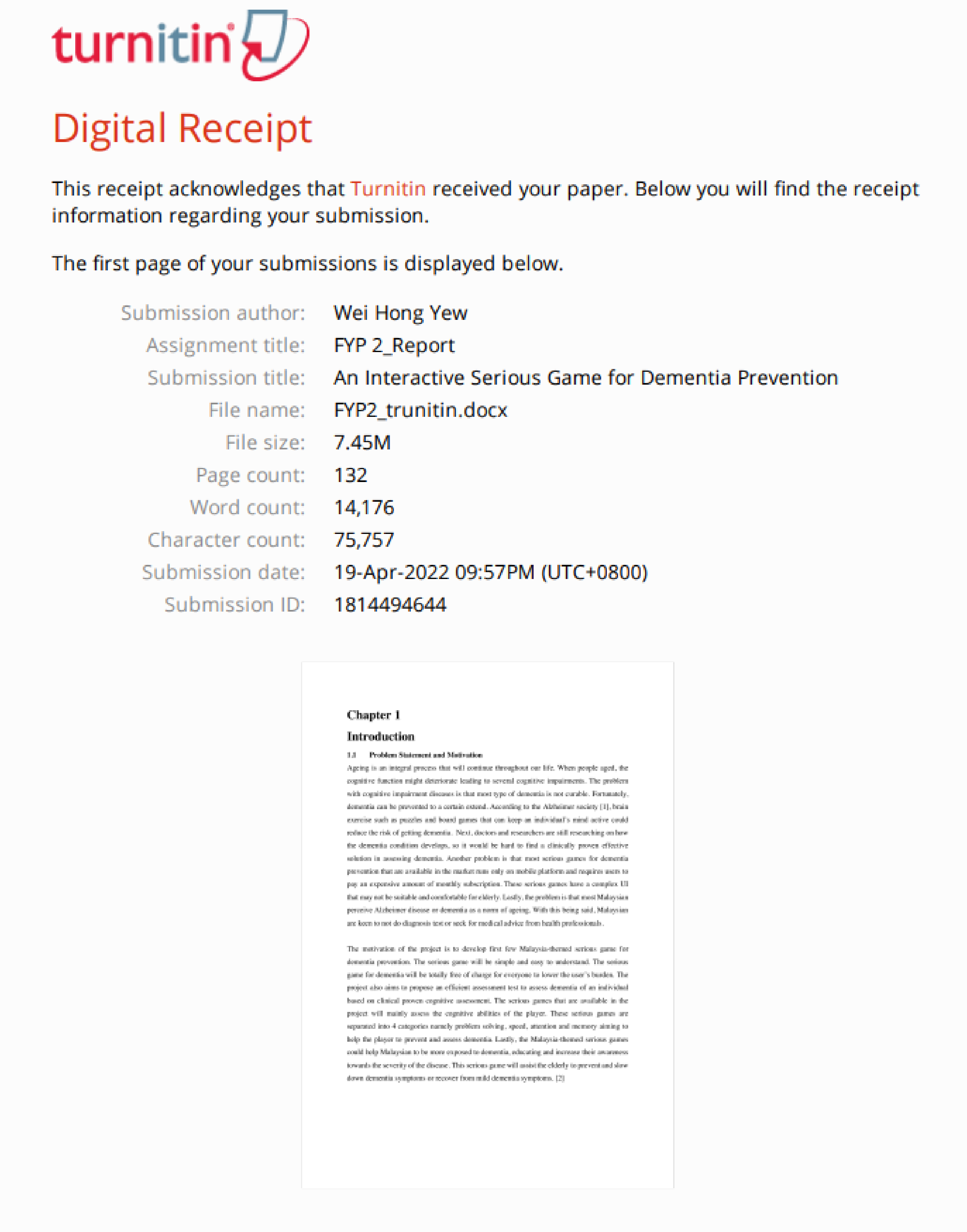
Conclusion

The serious game for dementia prevention is free, simple and Malaysia themed. The serious game can help users to prevent and reduce dementia.The serious game contain games grouped in different categories. Each categories will assess different areas of cognitive functionalities. The cognitive scores will be used as a measure of a person's cognitive abilities. The user's can also use their cognitive scores as a determinant if they potentially have dementia or not.

By Yew Wei Hong

FInal Year Report

PLAGIARISM CHECK RESULT



turnitin

Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	Wei Hong Yew
Assignment title:	FYP 2_Report
Submission title:	An Interactive Serious Game for Dementia Prevention
File name:	FYP2_trunitin.docx
File size:	7.45M
Page count:	132
Word count:	14,176
Character count:	75,757
Submission date:	19-Apr-2022 09:57PM (UTC+0800)
Submission ID:	1814494644

Chapter 1

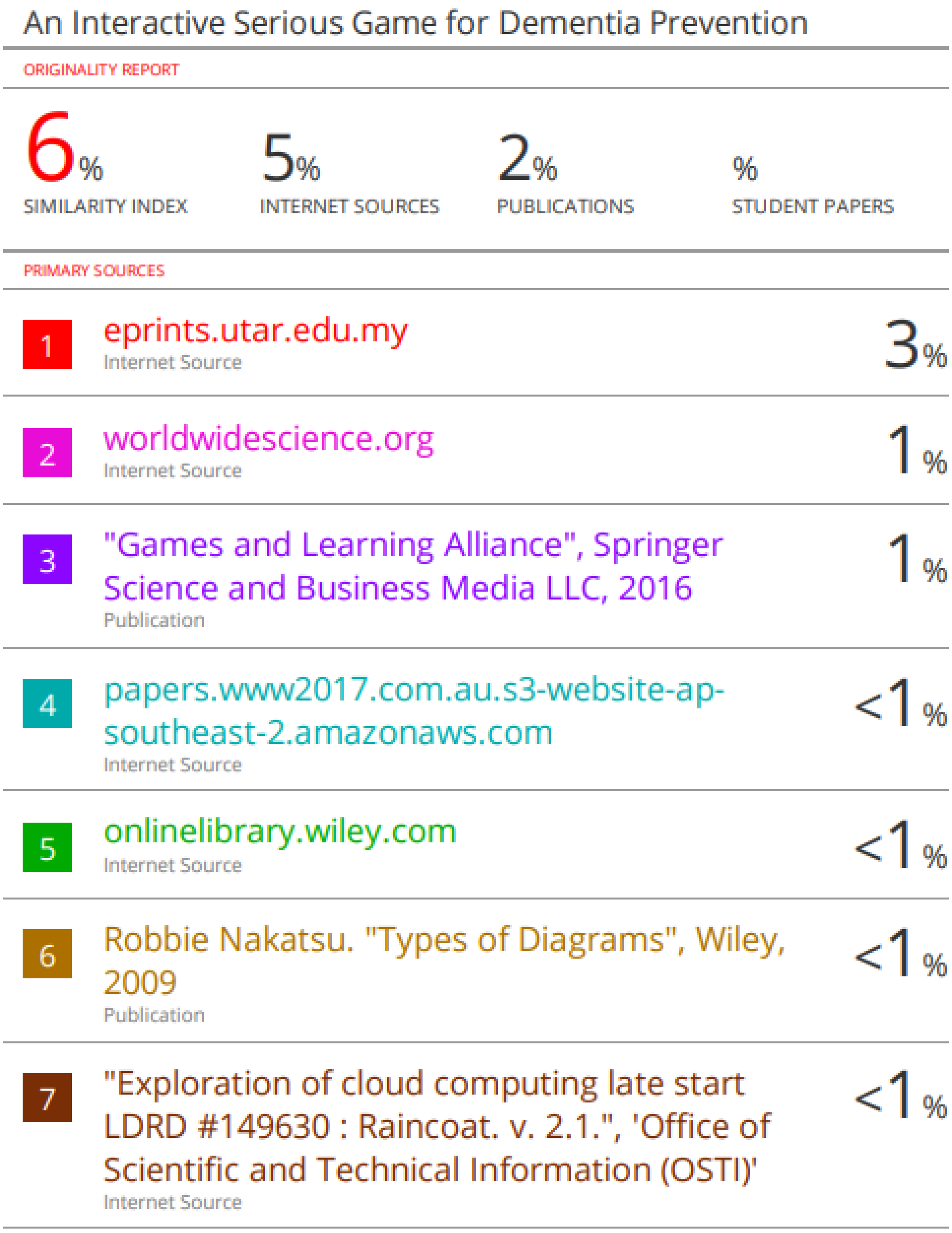
Introduction

1.1 Problem Statement and Motivation

Ageing is an integral process that will continue throughout our life. When people aged, the cognitive function might deteriorate leading to several cognitive impairments. The problem with cognitive impairment diseases is that most type of dementia is not curable. Fortunately, dementia can be prevented to a certain extend. According to the Alzheimer society [1], brain exercise such as puzzles and board games that can keep an individual's mind active could reduce the risk of getting dementia. Next, doctors and researchers are still researching on how the dementia condition develops, so it would be hard to find a clinically proven effective solution in assessing dementia. Another problem is that most serious games for dementia prevention that are available in the market runs only on mobile platform and requires users to pay an expensive amount of monthly subscription. These serious games have a complex UI that may not be suitable and comfortable for elderly. Lastly, the problem is that most Malaysian perceive Alzheimer disease or dementia as a norm of ageing. With this being said, Malaysian are keen to not do diagnosis test or seek for medical advice from health professionals.

The motivation of the project is to develop first few Malaysia-themed serious game for dementia prevention. The serious game will be simple and easy to understand. The serious game for dementia will be totally free of charge for everyone to lower the user's burden. The project also aims to propose an efficient assessment test to assess dementia of an individual based on clinical proven cognitive assessment. The serious games that are available in the project will mainly assess the cognitive abilities of the player. These serious games are separated into 4 categories namely problem solving, speed, attention and memory aiming to help the player to prevent and assess dementia. Lastly, the Malaysia-themed serious games could help Malaysian to be more exposed to dementia, educating and increase their awareness towards the severity of the disease. This serious game will assist the elderly to prevent and slow down dementia symptoms or recover from mild dementia symptoms. [2]

PLAGARISM CHECK RESULT



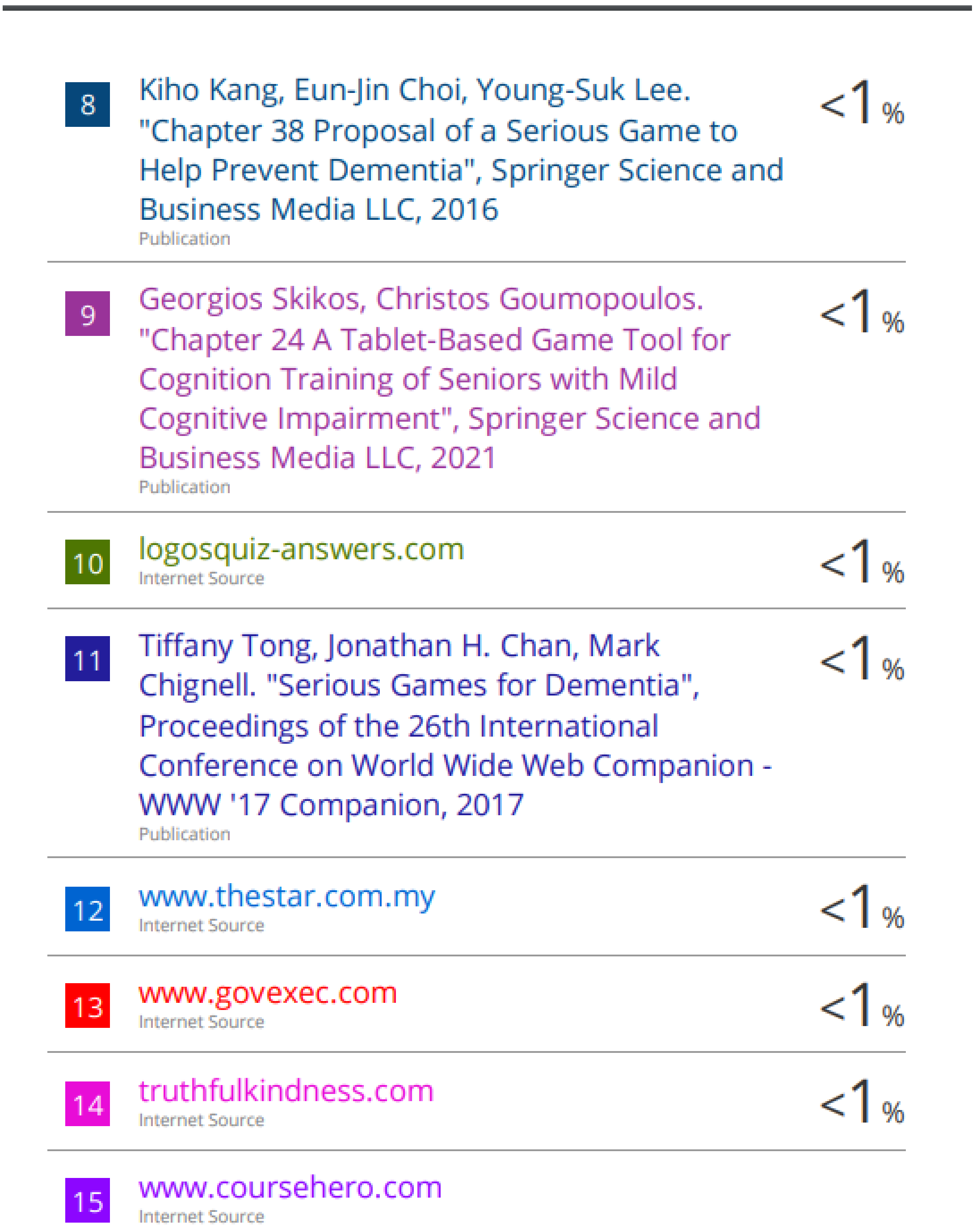
An Interactive Serious Game for Dementia Prevention

ORIGINALITY REPORT

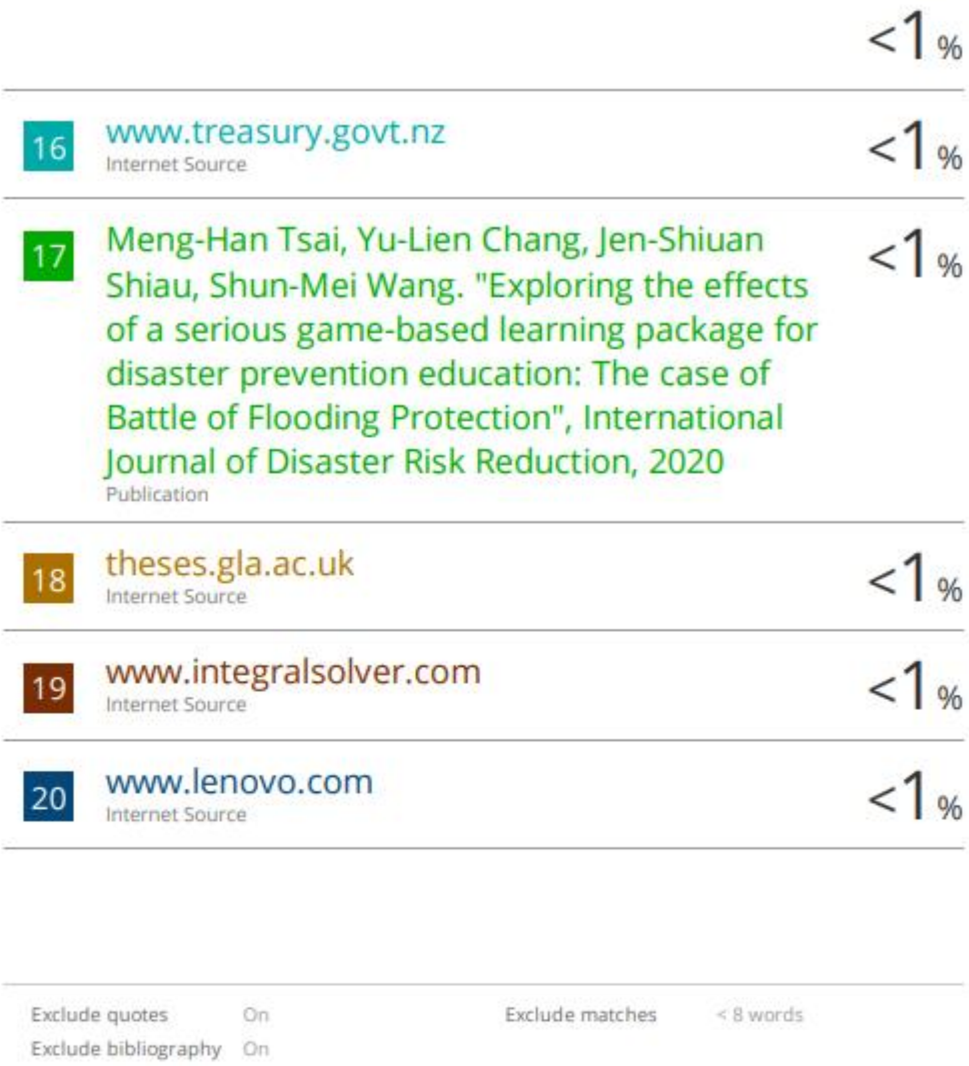
6%	5%	2%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	eprints.utar.edu.my Internet Source	3%
2	worldwidescience.org Internet Source	1%
3	"Games and Learning Alliance", Springer Science and Business Media LLC, 2016 Publication	1%
4	papers.www2017.com.au.s3-website-ap-southeast-2.amazonaws.com Internet Source	<1%
5	onlinelibrary.wiley.com Internet Source	<1%
6	Robbie Nakatsu. "Types of Diagrams", Wiley, 2009 Publication	<1%
7	"Exploration of cloud computing late start LDRD #149630 : Raincoat. v. 2.1.", 'Office of Scientific and Technical Information (OSTI)' Internet Source	<1%



8	Kiho Kang, Eun-Jin Choi, Young-Suk Lee. "Chapter 38 Proposal of a Serious Game to Help Prevent Dementia", Springer Science and Business Media LLC, 2016 Publication	<1 %
9	Georgios Skikos, Christos Goumopoulos. "Chapter 24 A Tablet-Based Game Tool for Cognition Training of Seniors with Mild Cognitive Impairment", Springer Science and Business Media LLC, 2021 Publication	<1 %
10	logosquiz-answers.com Internet Source	<1 %
11	Tiffany Tong, Jonathan H. Chan, Mark Chignell. "Serious Games for Dementia", Proceedings of the 26th International Conference on World Wide Web Companion - WWW '17 Companion, 2017 Publication	<1 %
12	www.thestar.com.my Internet Source	<1 %
13	www.govexec.com Internet Source	<1 %
14	truthfulkindness.com Internet Source	<1 %
15	www.coursehero.com Internet Source	



		<1%
16	www.treasury.govt.nz Internet Source	<1%
17	Meng-Han Tsai, Yu-Lien Chang, Jen-Shiuan Shiau, Shun-Mei Wang. "Exploring the effects of a serious game-based learning package for disaster prevention education: The case of Battle of Flooding Protection", International Journal of Disaster Risk Reduction, 2020 Publication	<1%
18	theses.gla.ac.uk Internet Source	<1%
19	www.integralsolver.com Internet Source	<1%
20	www.lenovo.com Internet Source	<1%

Exclude quotes	On	Exclude matches	< 8 words
Exclude bibliography	On		

PLAGARISM CHECK RESULT

Universiti Tunku Abdul Rahman			
Form Title : Supervisor's Comments on Originality Report Generated by Turnitin for Submission of Final Year Project Report (for Undergraduate Programmes)			
Form Number: FM-IAD-005	Rev No.: 0	Effective Date: 01/10/2013	Page No.: 1of 1

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Full Name(s) of Candidate(s)	Yew Wei Hong
ID Number(s)	18ACB04417
Programme / Course	Computer Science (CS)
Title of Final Year Project	An Interactive Serious Game for Dementia Prevention

Similarity	**Supervisor's Comments** **(Compulsory if parameters of originality exceeds the limits approved by UTAR)**
Overall similarity index: ___6____ **%** **Similarity by source** Internet Sources: ________5______% Publications: ______2______ % Student Papers: ________-_______ %	
Number of individual sources listed of more than 3% similarity: _____0____	
Parameters of originality required and limits approved by UTAR are as Follows: **(i) Overall similarity index is 20% and below, and** **(ii) Matching of individual sources listed must be less than 3% each, and** **(iii) Matching texts in continuous block must not exceed 8 words** ***Note: Parameters (i) – (ii) shall exclude quotes, bibliography and text matches which are less than 8 words.***	

Note Supervisor/Candidate(s) is/are required to provide softcopy of full set of the originality report to Faculty/Institute

Based on the above results, I hereby declare that I am satisfied with the originality of the Final Year Project Report submitted by my student(s) as named above.

Saw

____
Signature of Supervisor

Name: _____Ts. Saw Seow Hui_______

Date: _______21/4/2022____________

____
Signature of Co-Supervisor

Name: ___________________________

Date: ____________________________

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY (KAMPAR CAMPUS)

CHECKLIST FOR FYP2 THESIS SUBMISSION

Student Id	18ACB04417
Student Name	Yew Wei Hong
Supervisor Name	Ts. Saw Seow Hui

TICK (√)	DOCUMENT ITEMS Your report must include all the items below. Put a tick on the left column after you have checked your report with respect to the corresponding item.
	Front Plastic Cover (for hardcopy)
√	Title Page
√	Signed Report Status Declaration Form
√	Signed FYP Thesis Submission Form
√	Signed form of the Declaration of Originality
√	Acknowledgement
√	Abstract
√	Table of Contents
√	List of Figures (if applicable)
√	List of Tables (if applicable)
	List of Symbols (if applicable)
√	List of Abbreviations (if applicable)
√	Chapters / Content
√	Bibliography (or References)
√	All references in bibliography are cited in the thesis, especially in the chapter of literature review
√	Appendices (if applicable)
√	Weekly Log
√	Poster
√	Signed Turnitin Report (Plagiarism Check Result - Form Number: FM-IAD-005)
√	I agree 5 marks will be deducted due to incorrect format, declare wrongly the ticked of these items, and/or any dispute happening for these items in this report.

*Include this form (checklist) in the thesis (Bind together as the last page)

I, the author, have checked and confirmed all the items listed in the table are included in my report.

____
(Signature of Student)
Date:17/4/2022