



# The Development of Memory Mobile Games for Alzheimer's and Dementia Patients

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**Abstract:** Brain It On! – Memory Game is a memory games that can aid improve memory abilities while also providing an activity for the target user. This memory game is targeted elderly with age 60 and above. In this memory game, there are three mini game such as Flip Card game, Jigsaw Puzzle game and Quiz game. There are a few memory games available on the market, but they are all geared at children and teenagers. Other than that, most of existing games must be purchased in order to play the full version. The existing games also have high levels of difficulty, making it tough for the elderly to succeed and complete the game. This is due to the fact that the game is on a mobile phone, and the majority of the elderly do not know how to operate it. Therefore, Game Development Life Cycle (GDLC) is used as a methodology to develop this game. This methodology's phases are all appropriate for developing this game and ensuring its success. The result from user testing shows that the game is entertaining and the difficulty suitable for the elderly. However, there are a few things that might be improved to make the game better in the future.

**Keywords:** Alzheimer's, Dementia, Memory Game, Game Development Life Cycle

## 1. Introduction

Alzheimer's is a neurodegenerative disease that usually affects the elderly. Neurodegenerative disorders are illnesses that involve the death of certain parts of the brain. It compromises a patient's memory, his/her cognition, and perception of the environment[1]. There are few progressions of Alzheimer's disease, the first stage is Early (mild) stage. Alzheimer's disease usually begins with very minor changes in person's abilities or behavior. Next stage is Middle (moderate) stage, the changes become more marked and need more support to help them in their daily life. Last stage is Late (severe) stage, at this stage person with Alzheimer's will need even more help from others and gradually become totally dependent on others for nursing care. [2]

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Brain It On-Memory Game is developed as an activity to the elderly with memory problem. There are a few objectives that lead to the development of Brain It On-Memory Game. The objectives of this application are as follow:



1. To design 2-dimension BRAIN IT ON!- Memory Game using casual play mode.
2. To develop 2-dimension BRAIN IT ON!- Memory Game on android platform.
3. To test this 2-dimension BRAIN IT ON!- Memory Game to the target user.

There are a lot of activities that they suggest for person with Alzheimer’s disease to do with themselves, family, and caretaker. They also give activities that not suitable for person with Alzheimer’s disease. The suggest activity are games, exercise groups, brain games and baking.[3] In current situation, Covid-19 pandemic limit the patient’s activity and they cannot interact with family or people. They only can contact their family by call and video call. There are a lot of activity that they cannot do in this pandemic situation. Such as, gathering with family and open the care house for public visit. Hence, with this memory game they can fill their time with activity that are fun and help to increase their memory skills.


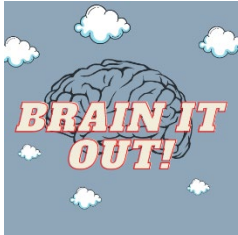
## 2. Literature Review

Developers should discover challenges or challenges experienced by users before designing an application or system, as well as compare and contrast the similar developed apps. Before we begin developing our own app, we must first discover the weaknesses of the analogous app so that we may enhance it. The comparison of the existing applications is shown in Table 1[4].

**Table 1: Comparative analysis between existing applications**

Application	Description
 <p>Lumosity: Brain Training [5]</p>	<ul style="list-style-type: none"> <li>• This application includes a lot of variety of memory game that can help Alzheimer’s and Dementia patient.</li> <li>• The challenges are memory, problem-solving, math, language, strengthen and quick.</li> <li>• But user needs to purchase premium package to access all the challenges.</li> <li>• User only can play three random challenges per day.</li> </ul>
 <p>Train your Memory [4]</p>	<ul style="list-style-type: none"> <li>• This game consists of eight interesting game that stimulate memory.</li> <li>• This game is suitable for all ages from children to seniors.</li> <li>• The game level will increase to make it more challenging.</li> <li>• User also can see the score that they obtain</li> </ul>

**Table 1: (continued)**

Application	Description
 <p>Brain Game for Adult [3]</p>	<ul style="list-style-type: none"> <li>• This game is a Logic puzzles solving using user’s memory game.</li> <li>• The categories that included in this game is Brain Focus, Think Fast, Retention, and Reflex.</li> <li>• Free user only can play free game. If user wants to continue, they need to purchase premium package.</li> </ul>
 <p>Brain It On! – Memory Game for Alzheimer’s and Dementia Patient</p>	<ul style="list-style-type: none"> <li>• This game is suitable for elderly because it uses only simple button and simple game.</li> <li>• Not every elderly knows how to use smartphone.</li> <li>• This game consists of three simple game which is Flip Card, Jigsaw Puzzle and What Is It?.</li> <li>• Every level in this game will increase the difficulties.</li> <li>• This game is developed in Android based.</li> </ul>

### 3. Methodology

The methodology used in developing this application is Game Development Life Cycle (GDLC) model. GDLC is a guideline which encompasses the game development process[6]. The Game Development Life Cycle is similar to the System Development Life Cycle (SDLC). The main difference is that it includes the media portion of the need, such as storyboard UI/UX, whereas the typical SDLC just focuses on the system's back end[7]. This methodology has five phases, which are Initial Phase, Pre-Production Phase, Production Phase, Testing Phase, and Beta Phase. All phases have their own task and function.

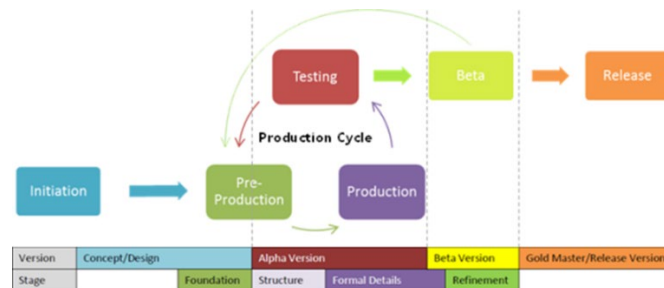


Figure 1: GDLC Model

#### 3.1 Initiation Phase

In this initiation phase, all the idea and concept for the game is decided in this phase. All the user and idea and concept will decide in this phase. With all the requirement, it will help during developing the game. The first idea for this game is the game will be in 2-Dimension(2D) and the targeted user are for the elderly that slowly developing dementia symptoms or elderly that have a good memory skill but want to have an activity with their family or caretaker. In this phase also, SME (Subject Matter Expert) named Jason Kang from Family Care Centre JB also been interviewed. All the requirement data gather is used and carry to next phase of the app named Brain It On!.

### 3.2 Pre-Production Phase

Pre-production is one of the first and foremost phase in the production cycle. The creation and revision of game designs, as well as the building of a game prototype, are all part of pre-production. In a game design document, the focus is on defining the game genre, gameplay, mechanics, plot, characters, obstacles, entertaining factors, technological components, and their documentation[6]. In this phase, it will take all the information from the previous phase to create the UI/UX design, flow of the apps, color, language, font, and feature of the app. All the information must be related and suitable to the target user.

### 3.3 Production Phase

In this phase the actual app development took place, programmers assimilate the requirements and specifications from the previous phase and produce actual code. The actual development will take place. The image file is being created using Adobe Photoshop, Adobe Illustrator, and Canva Pro. The app is being develop and test using Unity 2D as the app uses 2D style. The entire media file created is being imported to unity in png (transparent image) or Jpeg image format file. For audio, the file is in wav/Mp3 audio format. All the media is being used in a scene and some coding id being done using C# language. All the developed scene is being tested by using the Vivo S1 to ensure the correct output.

### 3.4 Testing Phase

In this phase, after the prototype is completed, it will be fully test scene by scene using the test plan document that produced using functionality and non-functionality requirement. All the flaw the identified is being fixed to ensure the application is developed well and function well. All the developed scenes will be tested by using Vivo S1 to ensure the correct output.

### 3.5 Beta Phase

In this phase, the completed application will be deployed to end user and user are required to fill a google form that have a set of question as their feedback. This game will be test to the elderly and the family or care takers. This testing will conduct online, this is because of the pandemic that happen in Malaysia. User can install the game after received apk file and they will answer the form to get the feedback.

## 4. Result and Discussion

This section presents the user analysis and testing that was conducted for Brain It On! – Memory Game.

### 4.1 User Analysis

User analysis is an activity that determining the characteristic of the user that may impact on the design of the interface. This user analysis is to understand the user more to give a great product in return. The goal for this user analysis is to understand their struggles, know the detail of circumstance and context, and gauge their reaction to this app.

Functional analysis is a process used to explain the functions of a complex system and a basic idea that the app will view as computing function. The requirement helps to capture the intended behavior of the system. This behavior may be expressed as functions, services or tasks or which system is required to perform. Table 2 and Table 3 shows the functional and non-functional requirements analysis of the application.

**Table 2: Functional Requirement Analysis**

Category	Detail
User Interaction	<ul style="list-style-type: none"> <li>If the user clicks on the button, they application will display what they click on.</li> </ul>

Game Module	<ul style="list-style-type: none"> <li>• If the user clicks on the exist button, the application will pop out the message “Do you want to exist?” and user will choose “yes” or “no”.</li> <li>• This game consists of three games that user can do. The games are <i>Pair It Out!</i>, <i>Jigsaw Puzzle</i> and <i>What Is It?</i>.</li> <li>• <i>Pair It Out!</i> – in this game, user need to flip the same card from all cards.</li> <li>• <i>Jigsaw Puzzle</i> – in this game, user need to drag and drop the puzzle piece to the correct place.</li> <li>• <i>What Is It?</i> – User need to click on the right image based on the question given.</li> </ul>
Game selection interface	<ul style="list-style-type: none"> <li>• This interface allows the users to choose which game that they want to play by click on the button.</li> </ul>
Autonomous system activities	<ul style="list-style-type: none"> <li>• After launching the supplication, the application will display the Main Page.</li> <li>• The game sound also on after user launch the game, they can off the sound if they want.</li> <li>• After user choose the game, the application will go to the game level.</li> <li>• After user complete the level, the success message will be appearing.</li> </ul>

**Table 3: Non-functional Requirement Analysis**

Non-Function Requirement	Description
Implementation	<ul style="list-style-type: none"> <li>• The application shall be able to launch on any 5.0 and above Android version.</li> </ul>
Performance	<ul style="list-style-type: none"> <li>• The application shall be able to respond in 3 second for most of the Android mobile.</li> </ul>
Usability	<ul style="list-style-type: none"> <li>• User shall be able to access to this application anytime and anywhere.</li> <li>• The application will provide the users an effective and enjoyable experience.</li> </ul>
Cultural	<ul style="list-style-type: none"> <li>• This application will user simple English.</li> <li>• There are few Chinese phases in Flip Card game to make easy for all races users.</li> <li>• This application needs to provide content that relatable about elderly.</li> </ul>

**Table 3: (continued)**

Non-Function Requirement	Description
Graphical User Interface Support	<ul style="list-style-type: none"> <li>• The system shall be able to support all kind of components of application such as graphics, animation, audio, and text.</li> </ul>



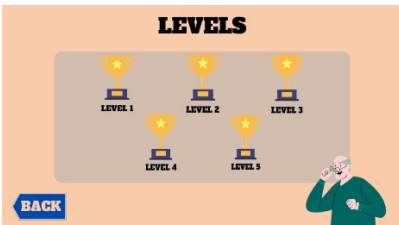
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- User only can view the information displayed in this application, but they cannot modify them.

#### 4.2 User Interface

This section will show all the interfaces that used in the application. The visual layout of the items that users may interact with within a website or technical product is referred to as user interface design, or UI. The target user's nature should be considered in the design. It should be appealing and easy to use. Table 4 shows the user interface design for this game.

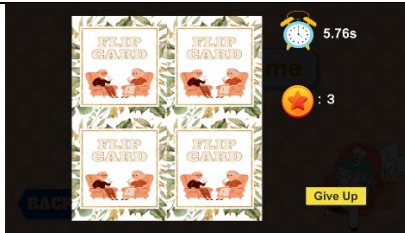
**Table 4: User Interface Design**

User Interface	Description
	<p><b>Home page</b></p> <ul style="list-style-type: none"> <li>• Consist of two main button which is play button, menu button and exit button.</li> <li>• User can exit the game by click on exit button.</li> <li>• The logo of the game is shown in the upper middle of the page.</li> </ul>
	<p><b>Game selection page</b></p> <ul style="list-style-type: none"> <li>• This page appears when user click on play button on Home page.</li> <li>• It allows user to choose which game they want to play.</li> <li>• The game available is Pair It Out!, Jigsaw Puzzle, and What Is It?</li> </ul>
	<p><b>Level selection page</b></p> <ul style="list-style-type: none"> <li>• This page appears when user click on one game button.</li> <li>• User can choose which level that they want to play.</li> <li>• But they need to play from low level to understand the game before continuing the game that have higher difficulties.</li> </ul>

**Table 4: User interface design**

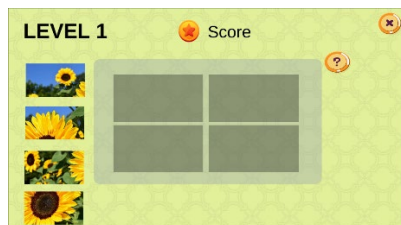
User Interface	Description
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***Pair It Out! Page***



- This game page, users need to search for the pair.
- If the user success to pair the card, one coin will be added in the score.
- The total card for each level will be increased to add the difficulty and challenge.

### *Jigsaw Puzzle Page*

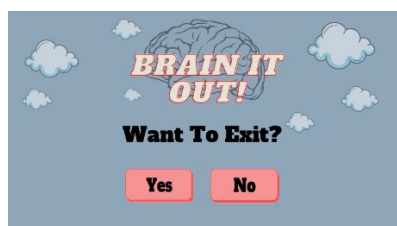


- This game page, users need to drag and drop the image to the image panel to make a correct image.
- There is hint button to give hint to the users during playing the game.
- If the user success the level, two coins will be added to the score.



### *What Is It? Page*

- This game page, user need to click on the right image from the question given.
- Users need to complete all the questions in 60 seconds.
- If the user clicks on right image, one coin added but if wrong, one coin deducted.



### *Exit page*

- In this exit page, two options are given to the users to pick whether they want to exit the game or continue in the game.
- If users choose to exit the game, the game closed.
- If users choose not to exit the game, the Home Page will appear.

## 4.3 Testing

Alpha and beta testing were conducted in order to ensure that the game functions properly. The developer conducted alpha testing throughout the development process until the project was completed, whereas beta testing was conducted after the project was completed with the participation of targeted users.

### 4.3.1 Alpha testing

To test the functionality and effectiveness of the application, alpha testing was conducted throughout the development process until the project was completed. The functionality of the buttons, the score, and drag and drop functionality in the puzzle game are all being tested during alpha testing. When errors are discovered during testing, improvements will be made to ensure that the problem is resolved. Table 5 shows the result of the Alpha testing based on all the functionalities in Brain It On!-Memory Game.

**Table 5: Result of alpha testing**

Test	Expected Result	Actual result	Corrective Action
Play button	Navigates to All Game scene.	Works as expected.	Not needed.
Exit button	Shows exit warning when clicked.	Works as expected.	Not needed.
Back button	Navigates to previous page.	Works as expected.	Not needed.
<i>Flip Card</i> button	Navigates to <i>Flip Card</i> game scene.	Works as expected.	Not needed.
<i>Jigsaw Puzzle</i> button	Navigates to <i>Jigsaw Puzzle</i> game scene.	Works as expected.	Not needed.
<i>What Is It?</i> button	Navigates to <i>What Is It?</i> game scene.	Works as expected.	Not needed.
Level button	Navigate to level that user want.	Works as expected.	Not needed.
Next button	Navigates to activity page.	Works as expected.	Not needed.
Home button	Navigate to All Game scene.	Works as expected.	Not needed.
Score	Add score for each correct answer.	Works as expected.	Not needed.
Hint button	Give hint in Puzzle game.	Works as expected.	Not needed.
Menu button	Display menu in the game.	Works as expected.	Not needed.
Sound button	On or Off the game's background sound.	Works as expected.	Not needed.
Info button	Display the developer's name.	Works as expected.	Not needed.
Drag and drop	Able to drag and drop answer selection to the answer box.	The letter/word cannot put back if it was drag from the answer column.	Make sure to click on check button to reset the answer column.

#### 4.3.2 Beta Testing

After the project was done, selected users were invited to participate in beta testing. The purpose of this testing is to obtain feedback from target consumers based on their game-playing experience. A collection of questionnaires was created using Google Form so that the data could be analyzed more easily with the help of auto-generated figures and charts. The test is conducted by distributing the questionnaire to the selected 10 respondents with 14 questions. Figure 2 – Figure 3 in **Appendix** section shown the target user test the game with their family. The information gathered from the questionnaire is then analyzed with System Usability Scale (SUS) [8]. The score is shown in Table 6.

**Table 6: The result of beta testing**



No	Respondent's score											Marks
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	
1.	5	5	5	4	4	5	5	4	4	5	3	49
2.	5	5	4	4	5	5	5	4	5	5	3	50
3.	5	5	5	4	4	5	5	4	5	5	4	51
4.	5	5	4	4	5	5	5	4	4	5	4	50
5.	5	5	4	4	5	5	5	4	4	5	4	50
6.	5	5	4	4	5	5	5	4	5	5	3	49
7.	5	5	5	4	5	5	5	4	5	5	4	55
8.	5	5	5	5	4	5	5	4	5	4	4	51
9.	5	5	5	5	5	5	5	5	4	5	4	53
10.	4	5	4	5	5	5	4	5	4	4	2	47
11.	5	5	5	5	5	5	5	4	3	4	3	49
12.	5	5	5	5	5	5	5	4	4	5	3	51
13.	5	4	5	5	5	5	5	4	4	4	3	49
14.	5	5	5	5	5	5	5	4	5	5	4	53
Total											707	

The formula used to get the usability result based on SUS is:

$$Y = \frac{P}{Q} \times 100\%$$

Where:

$P$  = Total scores of respondents for each question.

$Q$  = Total maximum of respondents scores.

$Y$  = Percentage score.

Therefore:

$$\begin{aligned}
 Y &= \frac{707}{770} \times 100\% \\
 &= 91.82\%
 \end{aligned}$$

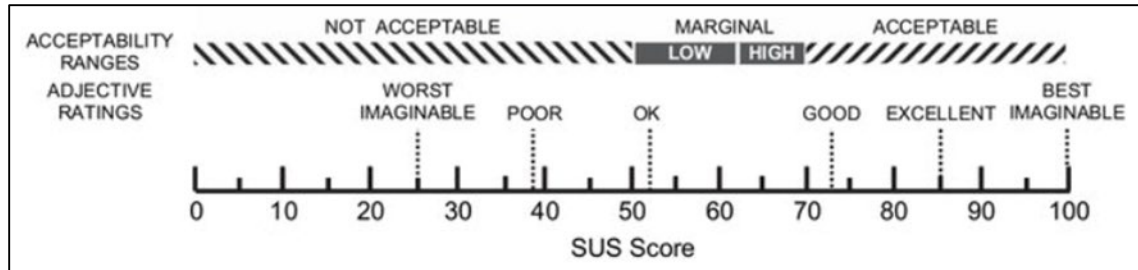


Figure 2: The scale of the SUS score

Based on the scale of the SUS score shown in Figure 2, the proposed application SUS score is acceptable.

## 5. Conclusion

Based on the findings, it can be stated that the Brain It On! - Memory Game has been built effectively. The results of Alpha testing suggest that the majority of the system is functional, with just a few adjustments to be considered for future enhancements. Also, the result of Beta testing using SUS got 91.82% which is in the acceptability ranges. The three goals set forth at the outset of this application's development have all been met. The application was completed successfully, including the game module. The benefits and drawbacks of using it have also been discovered. Finally, it is hoped that this application will improve more in the future.

## Acknowledgement

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## Appendix



Figure 2: User aged 83 years old



Figure 3: User plays the game with her family

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