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Final Report

FYP 16012
Open Crowdsourcing

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Summary

Dyslexia is a learning disability that caused by defeats in the brain processing different symbols and words [1]. Children with dyslexia are difficult to learn languages since the symptoms restrict their learning abilities and efficiency. As a survey conducted in Hong Kong, about 10% of children are suffering from dyslexia which deserves our concern. They ought to receive a proper support and be early discovered of the symptoms to minimize the effects of it to the patients.

The final report provides detailed information on the whole progress of the final year project, including the design and implementation. The team has developed a mobile application, called DyslexiaHero, which aims at improving children’s cognitive abilities through playing different game exercise and the collected game records provides an accurate assessment standard to deduce the normal abilities of children. The team targeted children who are studying in kindergarten because a research shows that the earlier the proper support to the children, the higher the improvement rate in learning. [2]

Dyslexia is characterised as five weak cognitive abilities in brain, including phonological awareness, processing speed, orthographic awareness, working memory and memory span [3]. Five game exercise concerning respective abilities are designed to test their performance on each ability and provide training before they attend the primary school.

Open Crowdsourcing is a key concept in the projects. It provides capability to decide a suitable level of assessment, giving an accurate estimation on abilities and analysing the weaknesses of the children.
Acknowledgement

We would like to express our greatest gratitude towards our supervisor Dr. T. W. Chim, for his support, advice and encouragement. We would also like to thank the Department of Computer Science of the University of Hong Kong, for the support provided throughout the whole course of this project.
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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>I/O</td>
<td>Input/Output</td>
</tr>
<tr>
<td>LTS</td>
<td>Long Term Support</td>
</tr>
<tr>
<td>SEN</td>
<td>Special Educational Needs</td>
</tr>
<tr>
<td>SpLDs</td>
<td>Specific Learning Difficulties</td>
</tr>
<tr>
<td>TTS</td>
<td>Text To Speech</td>
</tr>
<tr>
<td>UI</td>
<td>User Interface</td>
</tr>
<tr>
<td>VPS</td>
<td>Virtual Private Server</td>
</tr>
</tbody>
</table>
1. Background

In Asia, especially in Hong Kong, parents concern about their children’s academic results. If children did not obtain satisfactory academic results, parents may blame that they did not pay attention to class or they are “lazy”. However, there are many reasons leading to unsatisfactory academic results. Dyslexic is one of the reasons because it is a kind of Specific Learning Difficulties (SpLDs). Children with dyslexia, not only have difficulties in reading and writing words, but also have difficulties in distinguishing colors, similar words and processing things in their memory [3]. Due to lack of knowledge, parents may not bring their children to have a formal screening check and delay the most suitable time for the children to improve their cognitive skills. Even they notice that their children have the possibilities to be suffering from symptoms of dyslexia, they may not be affordable to pay several thousand dollars, especially for low-income families. Therefore, summarizing the situation, there is a need for a free-of-charge preliminary assessment platform which also provide training exercise against the lacking abilities.

Per research by Foorman, Francis, Shaywitz, Shaywitz, and Fletcher (1997), children with SpLDs gained a success rate of 82% if they received intervention in their lower-grade in primary school. However, for third grade to fifth grade students, the success rate has been lowered to 46% and for the higher-grade students, the success rate even drops to 10%-15% [2]. Once the children with dyslexia into primary school, they will feel difficult to learn than other students and get confused and distressed. It is understood that we should solve the problem as early as possible and prevent the severe situation to happen. Although kindergarten students may not have much opportunities to read or write, they still have basic idea to the alphabets, symbols and processing in memory.

For this project, the training exercise are embedded and represented as several mini-games. They are specifically designed for preschool to kindergarten children to improve different cognitive abilities. It is a user-friendly application for both parents and children. With different educational levels, the application will provide games with respective difficulties. Children will then improve their abilities and show the improvement in the game results if they play the games regularly and gradually. This project does not want to impose the concept of “win” or “lose” to the children and try to avoid this situation. No pass-fail line in the game allows children to enjoy the game content and have fun playing with the training exercise.
With the concept of crowdsourcing, the team can analyse how a normal child can perform at the age by calculating the average score. Comparing the children’s result with the average score, it is easy to find out their strengths and weaknesses than the normal standard. If the performance is too far away from the average score, parents may decide to bring their child to have a formal check. The best result is that the children with dyslexia can improve their cognitive abilities through playing the game exercise regularly.

A web analytic dashboard is included in the project and is opened to two type of people, researchers and parents. For the researchers, it shows charts on gender, education level distribution and average score on individual games. It can be used to decide the suitability of the game exercise for different group of children and look at the analysis from the game results. For parents, it shows charts based on their children’s performance in the game and parents can keep track on the performance and improvement rate on the children.

After collecting sufficient data in a longer period, it should be able to discover the weakest abilities of the dyslexic children and provide a better training method. The collected data is also used to analyse how dyslexic children could get the wrong answer.

The following paragraphs provide the details of the project, which includes the objectives, previous works evaluation, system design, game application content, deliverables, work accomplished and difficulties/limitation encountered.
2. Objective

The main objective of this project is to create a mobile application to improve the cognitive abilities of dyslexic children, helping them to adapt to learning in school. The application will provide games to determine the severity of dyslexia on every child. Through playing the games continuously, the children gradually develop their cognitive abilities. The rate of improvement for the games are recorded and the difficulties of games will be adjusted according to the rate of improvement. It will also help investigating the symptoms of dyslexia and raising the awareness of dyslexia to Hong Kong people. Also, a web analytics dashboard is created to visualize the game data and present the founding from the game results.

To investigate the symptoms of dyslexia, a large sample size of research materials is required. The materials for investigation are the incorrect answers given by the children in training exercises. From the large variety of game results collected, it is possible to discover the common mistakes made by children and understand the weakness of dyslexic children. By understanding the viewpoint of dyslexic children, it will be easier to develop learning tools for them and a better assessment method for dyslexia. Dyslexic children have difficulties in phonological awareness, processing speed, orthographic awareness, working memory and memory span. Analyzing the results of the exercise allows researchers to understand which abilities dyslexic children perform the worst and understanding which ability dominates the symptoms of dyslexia. The research facilities an improved strategy in dyslexia training. Dyslexic children can improve their abilities using suitable time on each area to maximize the efficiency of training.

The parent panel facilitates more parent-children interactions and monitors the results of the children. It is important in following up children’s performance. From collecting the scores of each game played, an average score will be calculated. It serves as a normal standard for children’s abilities. Parents can compare the results of their children with the normal standard to check whether their children having symptoms of dyslexia. Therefore, parents can keep track on game result and understand their children’s situation. The result will be kept secret since this project hopes to help dyslexic children to build confidence in learning and will not be discouraging dyslexic children by showing the game results.
The web analytics dashboard first helps the developers to understand the children’s performance by plotting the improvement rate of each game. The difficulty of the training exercises was originally designed to suit the educational level. And the developers will adjust the difficulty of the games after analyzing the effectiveness of the game exercise on the specific educational level. Moreover, researchers that study on dyslexia can also access to the web system to understand the characteristics of dyslexia, like the common mistakes and their features.
3. Previous Works Evaluation

In the mobile application market, some previous applications are available to help children with Special Educational Needs (SEN) and train their cognitive abilities to facilitate a better learning process. Some of the application are list as follows:

A) Galaxy Maze (Android) [4]

The mobile application helps the children with SEN to improve their memory and concentration through visual perception. The parents interact with children by providing missions and adjusting the starting point in the game. However, the interface is monotone and only one game mode can be selected to pair identical objects. Users suffer from duplicate game experience and reduce the interest in playing the game after some time.

B) Dyslexia Quest (iOS) [5]

The mobile application is specially made for dyslexic people and provides six games for testing memory and learning skills. The attractive interface and the smooth game flow are the advantages. The game analysis is clearly explained in term of abilities. However, the game targets people whose native language is English. People who have other native language are difficult in playing some of the games. The overall idea and game design are nice. However, the application is not general enough and not designed for preschool and kindergarten children.

C) Dyslexia Therapy (Android) [6]

The games are suitable for children to play since they are simple and instructive enough. However, it is bound with another software Adobe Air in order to start the game which is not independent and inconvenient. And the games are not smooth and attractive.

From the previous works, developers implement several ideas to assist SEN students in improving the learning abilities. The disadvantages from previous works are unattractive interface, insufficient game modes and repeated game contents. This project should avoid making the mistakes and take advantages of the good features of previous works.

Features like parent panel and the games which training different cognitive abilities are worth as reference and to be implemented in this project. Performance analysis is another good feature that should be implemented in this project. The children’s abilities can be clearly shown and parents can compare children’s performance easily. Finally, since the project targets preschool to kindergarten, the interface must be interesting and colourful to attract them for continuous training.
4. System Design

In this session, it explains the system design including system architecture, methodology and approach used in this project.

4.1. System Architecture

In this project, it has a client-server architecture (Figure 1). It mainly constructed by four components:

A) Node.js

It is an open-source JavaScript runtime environment. It is used to build the server in this project for handling requests from the application, storing and receiving data from MongoDB.

B) Socket.io

It is a JavaScript library that enables bidirectional event-based communication. One part of Socket.io is used as a server-side library for Node.js server. Another part is for the client-side application.
C) MongoDB

It is an open-source, document-oriented database program. It is used to store all the data in this project including user registration information, players’ scores and game questions.

D) Express Application

It is a flexible and minimal web application framework based on Node.js. It is used to invoke series of middleware functions and to visualize the game statistics.

Why Node.js and MongoDB?

There are many ways to implement a client-server architecture and Node.js with MongoDB is not the only method. A common approach is using MySQL with PHP. After comparing the performance between Node.js with PHP in Figure 2, Node.js shows a lower processing time than PHP, which means Node.js performs better than PHP.

![Node.js vs PHP Performance](image)

**Figure 2 - Node.js VS PHP Performance**

After selecting the scripting language, the database performance also affects the performance of the system. By comparing the INSERT query between MySQL and MongoDB in Figure 3, MongoDB shows a significant better result than MySQL. Also, comparing the select query in Figure 4, MongoDB performs better.
The team decided to use MongoDB with Node.js because it shows a high flexibility, high scalability and better performance when processing large amount of data.

(For details, please refer to Lam Wan Yiu Enid’s report)
4.2. Methodology

4.2.1. Handwriting Recognition

The handwriting recognition is performed using $P$ Point-Cloud Recognizer [7]. It is originally developed to determine gestures written by the users. The recognizer can be implemented as C# in the unity. After testing with the $P$ Point-Cloud Recognizer, it shows its ability to distinguish the alphabets after adding the handwriting gestures.

The $P$ Point-Cloud Recognizer is a 2-D recognizer which record the writing in terms of point (x-axis, y-axis) and each line has its own stroke ID. The points generated from user’s handwriting are matched with a set of standard templates by nearest-neighbour classification rule. There are already templates for each of the character in alphabets. Figure 5 illustrates the matching points between two handwriting and templates.

![Figure 5 - $P$ Point-Cloud Recognizer Illustration](image)

Then, the recognizer will return the matched templates and provide a matching value which represent how similar between the handwriting and the templates. The matching value ranges between 0 and 1. The team make use of the $P$ Point-Cloud Recognizer to deduce the correctness of the children’s handwriting.
4.2.2. Question Generation
Dyslexic children have difficulties in processing words and graphics. When they read, they see at a different viewpoint than the others, causing them difficult to recognize and remember words [8]. For example, they get confused with “p” and “d”, “mood” and “doom” [9].

In the writing game, children write the characters as the requirement of the game exercise. As the handwriting are determined in term of lines of points, the team has to regenerate the line between the points making use of the common equation making use of slope = (y1-y2)/(x1-x2) and then the team has darkened the line to show a better graphical result. After the handwritings are converted to PNG in client side, they are sent from the application to the database through JSON in byte array and stored in the server as PNG again. Those wrongly written characters are good examples of wrong recognition of dyslexia. The correctly and wrongly written character are reused for the reading game.

In the reading game, user is needed to choose a correct answer among several incorrect answers. Totally 4 choices are generated. One of the choice will be generated with all characters correctly written. The other three choices will randomly be assigned different number of wrong characters in it. There is at least one wrong character in each choice to ensure the overall choice is wrong.

Figure 6 shows examples of words generated from the grouping of characters. Thus, more questions can be automatically generated. In theory, infinite number of questions can be generated if more and more children play the first game. This makes the game contents flexible and interesting because players will experience new questions every time they played.
4.2.3. Data Visualization

The team implemented a web analytics dashboard called D3.js. It is a tool for rendering different charts and graphics to a web page. It contains a library to transform fetch data from MongoDB and can present certain groups of data. Crossfilter and dc.js are the main libraries for constructing the interactive charts and provides an extremely fast way to manipulate data. Dc.js let user choose different types of charts such as bar chart, line chart and pie charts. With the combination of these three libraries, the web analytics dashboard can provide fast, efficient, and user-friendly data analysis.

4.2.4. User Motivation

For the first time of playing, user is required to complete all five games before they can freely play other games. Then, a full assessment result concerning five different abilities can be produced and stored in database. However, to motivate the children to continue to play our games, the team has imposed a coin system. Player will be awarded of 10 to 30 coins, respectively to one to three stars, based on game performance. Player is allowed to buy new hero character in the shop menu and browse around the game world.

To keep track to the improvement of children’s abilities, the best situation is that the children play all five games evenly. Therefore, player will be awarded bonus coins of 100 if they finished all the fives and counter will be reset.

The team also makes a calculation on the selling prize of hero character to maximize our desired results. If player perform perfectly in all five games, he or she is awarded of 30*5+100 = 250 coins. Therefore, all the prices of characters are the multiple of 250 coins. Currently there are totally 8 characters including the default two characters, which were originally used as indicating the gender. The team proposed that rate of improvement from the assessment result are steadily shown if the children play more than ten times per game.
4.3. Development Platform

The server is hosted in a Virtual Private Server (VPS) provided by Digital Ocean. The Node.js server, MongoDB and web application are stored in the VPS. It utilized the Ubuntu LTS 14.04 operating system. The web analytic dashboard is developed based on the Express framework.

The main game application is developed using Unity, which supports C# and JavaScript programming language. It can export to cross-platform, including Android, iOS, Linux, Windows etc.

The testing platform of the application is iPad mini with iOS 8.

5. Game Application Content

The main functions of the application are the game exercises and parent panel. Initially, the application requires users to complete a first-time registration for the children’s educational background, for example, name, gender, age and education level. It is also required to register for an account to enter the parents panel by providing the username and password.

5.1. Game Design

The education levels are divided into three section: Beginner (preschool), Intermediate (K1-K2) and Advanced (K3). The difficulties of game exercise are determined according to the education level. Five game exercise are provided in total and each game aims at improving a specific category of weak abilities. The questions are randomly generated to avoid duplicate game experience. And the children are highly recommended to finish all the game exercise once to record the performance in all the abilities. Then the children can freely play all the game exercise.

Since the application target young children at the kindergarten level, they may not be able to fully understand the word on the screen. Therefore, the team provides some verbal instructions to guide the young users. A text-to-speech (TTS) extension will be used for generating voice dialogue. The details of the game exercise are as follows (Table 1):
<table>
<thead>
<tr>
<th>Category</th>
<th>Meaning</th>
<th>Game Content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phonological Awareness</strong></td>
<td>Ability to manipulate meaningful sounds in English</td>
<td>Identify whether two words are the same or different</td>
</tr>
<tr>
<td>(Word Discrimination and Rhyme)</td>
<td></td>
<td>Identify whether two words are the same, different or rhyme</td>
</tr>
<tr>
<td><strong>Processing Speed</strong></td>
<td>Ability to solve tasks provided quickly</td>
<td>Showing three type of objects with different color, ask the user to drag the specific objects on the screen and drop it to specific area as much as he/she can in a minute</td>
</tr>
<tr>
<td>(Visual Scanning Task)</td>
<td></td>
<td>Showing four type of objects with different color, ask the user to drag the specific objects on the screen and drop it to specific area as much as he/she can in a minute</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Showing five type of objects with different color, ask the user to drag the specific objects on the screen and drop it to specific area as much as he/she can in a minute</td>
</tr>
<tr>
<td><strong>Orthographic awareness</strong></td>
<td>Ability to form, store and recall words</td>
<td>Showing words with length of two to four with similar appearance and ask the user to pick the correct one</td>
</tr>
<tr>
<td>(Recognizing Different Length of Words and Writing the Alphabets)</td>
<td></td>
<td>Asking the user to write the letters of the alphabet</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Showing words with length of three to five with similar appearance and ask the user to pick the correct one</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asking the user to write the letters of the alphabet</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Showing words with length of four to six with similar appearance and ask the user to pick the correct one</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asking the user to write the letters of the alphabet</td>
</tr>
</tbody>
</table>
### Working memory (Message Transform)

| Ability to remember and transform the information at the same time | Two to three symbols will be presented in sequence and ask the user to recall them in reverse order | Two to four symbols will be presented in sequence and ask the user to recall them in reverse order | Two to five symbols will be presented in sequence and ask the user to recall them in reverse order |

### Memory Span (Span Task)

| Ability to receive the verbal information and repeat it | Present two to three tasks verbally and ask the user to do the tasks in sequence | Present two to four tasks verbally and ask the user to do the tasks in sequence | Present two to five tasks verbally and ask the user to do the tasks in sequence |

---

**5.2. Parent Panel**

The parent panel is protected by the password and children are not able to assess to parent panel. After the children, has completed all five games, parents can view their children’s performance clearly in a radar chart.

As the results are uploaded to the database for calculating the average score among the students with same educational level, parents can compare their children’s result with the average score (Figure 7). If the score is significantly below average, it represents that the child has difficulties in that specific ability.
6. Deliverable

The deliverables of this project are shown below.

<table>
<thead>
<tr>
<th>Date</th>
<th>Deliverable</th>
<th>Description</th>
</tr>
</thead>
</table>
| 2 October 2016        | Phase 1 (Inception)                              | Detailed project plan: It provides the project background, objectives and methodology in detail. 
                          | • Detailed project plan                          | Project web page: It provides the update of the project progress.          |
|                       | • Project web page                               |                                                                             |
| 22 January 2017       | Phase 2 (Elaboration)                            | Preliminary implementation: The server, database setup, web analytics dashboard and basic functions of the game application are implemented. 
                          | • Preliminary implementation                      | Detailed interim report: It reports the progress and implementation in detail. |
|                       | • Detailed interim report                        |                                                                             |
| 16 April 2017         | Deliverables of Phase 3                          | Finalized tested implementation: The application and the web system are tested and optimized. The implementation will be released and finalized. 
                          | (Construction)                                    | Final report: It includes all the details about the final project.         |
|                       | • Finalized tested implementation                |                                                                             |
|                       | • Final report                                   |                                                                             |
7. Work Accomplished

The project has already been done. The overall work accomplished is shown in the table below (table 3). The research on dyslexia, previous works and feasibility have been done and the project website has been set up. The server and database setup has been done. For the application, the first-time registration, interactive menu and one the five games have been implemented and tested. For the web analytics dashboard, the interface charts based on the data on MongoDB have been done and now controlling the questions of orthographic awareness.

<table>
<thead>
<tr>
<th>Work Accomplished</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research on dyslexia, previous works and feasibility</td>
</tr>
<tr>
<td>Project Website</td>
</tr>
<tr>
<td>Prototype</td>
</tr>
<tr>
<td>Server and Database Setup</td>
</tr>
<tr>
<td>Game Application</td>
</tr>
<tr>
<td>First-time registration</td>
</tr>
<tr>
<td>Interactive Menu (Parent Panel, Shop Menu, Option Menu)</td>
</tr>
<tr>
<td>Processing Speed</td>
</tr>
<tr>
<td>Orthographic Awareness</td>
</tr>
<tr>
<td>Working Memory</td>
</tr>
<tr>
<td>Memory Span</td>
</tr>
<tr>
<td>Processing speed</td>
</tr>
<tr>
<td>Background music and sound effect</td>
</tr>
</tbody>
</table>
7.1. Server and Database Setup

The server of this project is Ubuntu LTS 14.04 server which has been installed in the virtual machine provided by DigitalOcean. The Node.js v6.9.2 environment and socket.io v1.7.2 have been installed in the server. The database system, MongoDB 3.0.14, has been installed. Mongoose is used as an object modelling package for Node.js.

The schemas of the data are defined as follow:

```javascript
var proSpdSchema = new mongoose.Schema({
    nthPlayed: {type:Number, min:0},
    date:{type:String},
    score: {type:Number, min:0},
    taskCompleted: {type:Number, min:0},
    numOfCorrectTask: {type:Number, min:0}
});

var gameSchema = new mongoose.Schema({
    nthPlayed: {type:Number, min:0},
    date:{type:String},
    score: {type:Number, min:0},
    numCorrectTask: {type:Number, min:0}
});
```
var userSchema = new mongoose.Schema({
  uid: {type: String, trim: true},
  name: {type: String, trim: true},
  username: {type: String, trim: true},
  password: {type: String, trim: true},
  userType: {type: Number, default: 1},
  gender: {type: Number, min: 0},
  eduLv: {type: Number, min: 0},
  dateCreated: {type: String},
  proSpd: [proSpdSchema],
  phono: [gameSchema],
  ortho: [gameSchema],
  workMem: [gameSchema],
  memSpan: [gameSchema]
}, { collection: 'users' });

var rhymingWordsSchema = new mongoose.Schema({
  ending: {type: String, trim: true},
  words: {type: Array}
}, { collection: 'rhymingWords' });

var dictionarySchema = new mongoose.Schema({
  word: {type: String, trim: true}
}, { collection: 'dictionary' });
var alphabetImageSchema = new mongoose.Schema({
    png: {type:String, trim: true},
    character: {type:String, trim: true},
    noOfPlay: {type: Number, min: 0},
    noOfChosen: {type: Number, min: 0},
    correctness: {type: Number, min: 0},
    status: {type: Number, min: 0},
    dateCreated: {type: Date}
}, {collection: 'alphabetImage'});

The gameSchema represents each of the game records. The userSchema represents each of the users, which included multiple game records of different type of games. The letterSchema represents each handwritten image of the letter. The orthoSchema represents 26 letters, which included multiple handwritten images of each letter. The phonoSchema represents a list of rhyme words. The dictionarySchema represents each word from the dictionary. The alphabetImageSchema represents each alphabet Image stored in the database.
7.2. Game Application

7.2.1. Starting Screen

Figure 8 shows the starting scene. When user press the bottom right rubbish bin button, the application will ask the user whether he or she want to delete the original game data. User thus can choose to open a new account. If there is no game data in the game application, user should register for a new account in 7.2.2. Registration. If there is already game data in it, user will directly go to 7.2.4 Interactive Menu.

7.2.2. Registration
In the registration menu, user is required to input their name, gender and education level for their children (Figure 9). Then, user can enter the username and password for entering the parent panel in the future. All the information will then be sent to the server and insert a record in the database.

7.2.3. Story

The story line of the game is shown after user register from 7.2.2 Registration. It is used to attract the children to enjoy the game with an interesting story. The story is about a knight rescuing the castle which is invaded by the monster. The knight needs to clear all the game level to knock down the final boss.
In this part shown in Figure 11, user can move with his or her character in the map with left and right arrow button. For the up-arrow button, the character can make a two-step jumping and browse around the map. There is an “fire” button at the bottom right corner of the scene. The button is used to enter the game exercise when the hero character arrives the destined location. There are two doors in the game which required the key to open. The key can be collected when user finished the task at the door and be used to enter the door using the “key” button.

Pressing the upper right corner of the scene leads user to the option menu, while user can adjust the volume of the sound and music. In the option menu, there are three buttons, from left to right indicating going to 7.2.11 Parent Panel, 7.2.1 Starting Scene and continue in the interactive menu.

Pressing the shopping cart buttons will lead player to 7.2.10 Store.

On the upper left corner, there are 5 icons indicating which games are finished currently.
7.2.5. Processing Speed

The game exercise trains children’s processing speed. Processing speed determines how fast people take into new information and respond to the information. In this game, the information is the items with different color and size. Children are needed to determine and collect the items on the screen and drag the items to the bag to collect the items (Figure 12). The system will deduce whether the child drag the correct or wrong items. There are three to five types of items in different color based on the difficulties. The time limit is one minutes and children can freely drag the items to the bag during the time.

7.2.6. Phonological Awareness

The game exercise trains children’s phonological awareness. Phonological awareness is the ability to perceive, manipulate, and think about the individual sounds in spoken language. In this game, children are asked to listen to the words and identify whether two words are the same, rhyme or different (Figure 13).
The game exercise trains children’s phonological awareness. Phonological awareness refers to the awareness to sound. There are totally ten questions. For every question, children will listen to the words and identify them whether they are the “Same”, “Rhyme” and “Different” and press the respectively one.

7.2.7. Orthographic Awareness

![Figure 14 - Orthographic Awareness 1](image1)

The game trains children’s orthographic awareness. Orthographic awareness refers to the ability to store, form and assess the orthographic representation. One of the daily example utilizing the ability is reading and writing. Thus, the game is divided in two part: I) children will be shown a word and should choose the correct answer among the multiple choice and II) player should write the alphabet as requested (Figure 14).

![Figure 15 - Orthographic Awareness 2](image2)
After loading the question data from the server, the scene will show the targeted word and then it will provide 4 choices for player to select (Figure 15). The question mark button allows the player to review the word again if they forget the word. If the player chooses the incorrect answer, the monster at bottom right corner will shoot an arrow indicating that the question is wrong. After completing five questions, it will process to another half of the game exercise.

![Figure 15](image)

**Figure 16 - Orthographic Awareness 3**

In this section, players are required to write the alphabets shown in the screen (Figure 16). With the same function of the question mark button, players can review the alphabet that player should write. If players press the rubbish bin icon button, it will clear the original writing and players can rewrite it again. The tick button is the submit button. After it submits, the application will use $P$ Point-Cloud Recognizer to recognize the character written. If the player write a character which is deduced as wrong by the system, the monster will shoot an arrow to indicate that the question is wrong. The children would write five characters in total.
7.2.8. Working Memory

![Figure 17 - Working Memory 1](image)

The game trains children’s working memory. Working memory refers to the cognitive ability to process the information held in the brain. In the game, the information is the reverse order of sequence of the symbols located on the screen (Figure 17). Ten questions are provided. Three sets of symbols are provided and they are numbers from 0 to 9, characters from a to j, and another 10 random icons.

![Figure 18 - Working Memory 2](image)

In this game, the game shows a sequence of buttons indicating in green color. Then players are required to press the corresponding button in reverse order. There will be a “start” popping out to indicate that the buttons are available. Players should play ten 10 game levels while the symbols are changed between consecutive game levels.
7.2.9. Memory Span

The game trains children’s memory span. Memory Span refers to how long list the items a person can memorize the correct order in the brain. The item would be the sequence of number 1 to 6 and alphabets from a to f. In the game, the locations of the items are randomly generated on monster body.

Upon the start of the game, player will hear a list of items and record them in their brain. Then, player will press the corresponding part on the monster body to hit the monster. If player press the correct area, the items shows green color. Or else, it shows red. After each game level, if the player make a mistake in remember the item lists, the monster will be animated to attack.
7.2.10. Store

**Figure 20 - Store In Game**

The store provides different hero characters for players to buy and is used to attract the children to continue to play the game. The coins are collected according to the coins earned from playing the game exercise. Players are also able to change the character if they have bought it and press the “USE” button to activate the character.
7.2.11. Parent Panel

The parent panel are protected by the password and suppose that only parents can look at the performance of their children in the game exercise. The scores are represented in radar chart. The parents can compare with the average score of their children with the score of the children to understand the strengths and weaknesses. If there is deficiency in most of the areas, it has a high possibility to be the symptoms of dyslexia.
7.3. Web Analytics Dashboard

The web analytics dashboard has two main functions:

1. Analyze game records and statistics (Data Visualization)
2. Show common mistakes from users

The interface of the data visualization is shown above (Figure 13). There whole interface contains 8 charts:

1. Number of Players by Date Created (line chart)
2. Number of Players by Education Level (row chart)
3. Players’ gender distribution (pie chart)
4. Average score of Processing Speed by nth Game Played (bar chart)
5. Average score of Phonological Awareness by nth Game Played (bar chart)
6. Average score of Orthographic Awareness by nth Game Played (bar chart)
7. Average score of Working Memory by nth Game Played (bar chart)
8. Average score of Memory Span by nth Game Played (bar chart)

Users of the dashboard can select one or more target groups for analysis by clicking on the regions on the charts. For example, if the user want to analyse the performance of K2 boys, then they can select “K2” on chart 2 and select “male” on chart 3. The result is shown in Figure n+1.

![Figure 23](image)

**Figure 23 - Panel Showing Result of Orthographic Awareness**

A tab naming Orthographic Awareness displays the information with corresponding game exercise. A table including the image, file name, corresponding character, correctness, status and wrong rate (if wrong) is shown. The researcher can switch the alphabet image with three status, Finished, In Use and Idle as all the alphabet images are default set as Idle when they were stored in the database. Therefore, when researcher search for character a which is IN Use, it shows up the targeted information. They can compare the wrong rate to compare how the children mix up the correct alphabet with the wrong alphabets writing. For example, in the figure, 110.png shows a higher wrong rate than a_2.png which means more children wrongly recognize the image as the character a.

With the panel, researcher can choose the desire set of alphabet images from Idle state to be In Use to test. This allows systemic researches to check how children respond to different wrongly written character.
8. Difficulties/limitation Encountered

**TABLE 4 - Difficulties/limitation encountered**

<table>
<thead>
<tr>
<th>Difficulties/limitation</th>
<th>Impact</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unable to perform the handwriting recognition using the neural network approach</td>
<td>Medium</td>
<td>Since the scripting language of Unity is JavaScript and C#, it is hard to find the perfect approach in these two language. (Mostly in python) Therefore, the team search for another approach that can recognize the handwriting and observe that $P$ Point-Cloud Recognizer is good enough and implemented in the game application.</td>
</tr>
<tr>
<td>Insufficient data from the formal dyslexia screening test materials in Hong Kong for reference</td>
<td>Low</td>
<td>As the formal assessment tool in Hong Kong could only be used by registered educational psychologist and clinical psychologist, the team cannot access the assessment materials directly. Therefore, the game design will be based on the reference books in foreign countries.</td>
</tr>
<tr>
<td>Unfamiliar with the development tool</td>
<td>Medium</td>
<td>More time was spent on learning the development tool and estimating the feasibility of the project.</td>
</tr>
<tr>
<td>Difficult in considering the number of games included. Develop excessive games leads to the team may not be able to finish it on time</td>
<td>Low</td>
<td>Five mini games were decided because each game tests each of the weak abilities of dyslexic children. They cannot be joined together because it affects the result of assessment or training. To ensure the progress, each game exercise is represented as mini games to reduce development time.</td>
</tr>
<tr>
<td>Inconvenient in cooperating with a Unity project between members</td>
<td>Low</td>
<td>After discovering the problem, the team find a latest beta version of Unity Collaborate. It allows small team to save, share, and sync the Unity project. Therefore, the team has joined the open beta to obtain this feature.</td>
</tr>
</tbody>
</table>
9. Conclusion

By developing interactive and interesting application, dyslexic children can learn and improve their cognitive abilities through game exercise. It is hoped that with the free assessment, more parents can understand what dyslexia is and utilize the assessment features to spot the sign of dyslexia on their children. Parent-child interaction consolidates the relationship between them. The project aims to give help to the dyslexic children.

Besides, the web analytics dashboard act as a key tool for analyzing children’s performance and evaluate the effectiveness of the games. With the feature of data visualization, the analysis process becomes easier and more efficient. Its facilitates the research of improving the efficiency of training by giving suitable training exercise.

Currently, the prototype of the application has been finished. The database and server has been set up on a VPS. The first-time registration function and one of the five games have been implemented and tested. The communication between the application and server can work normally and the message containing game result is successfully sent. For the web analytics dashboard, the charts can be successfully rendered.

Summarizing the report, although several functions have not been implemented, the project is progressing on schedule. Most of the difficulties encountered have been solved by the effort of the team. Future tasks will focus on developing rest of the games. More considerations on the game interface design and audio effects are needed to provide better game experience.
References

[1] Siegel LS. Perspectives on dyslexia. Paediatrics & child health. 2006;11(9);591–587.


Appendices

Appendix I: Flow chart of the game application

Flow chart of the application:

![Flow chart of the game application](image)

**Figure 24 - Flow chart of the game application**