Final report

FYP 16012

Open Crowdsourcing

Individual Report
by Lam Wan Yiu Enid

Supervisor
Dr. T.W. Chim

Group Members
Lam Wan Yiu Enid 2013559206
Chan Ho Wah David 2013500956

Date of Submission
16th April 2017
Summary

Dyslexia is a learning disability that affects the brain in processing words and graphics [1]. Children with dyslexia have serious difficulties in learning languages, including reading, speaking, listening and writing. In Hong Kong, 9.4% to 12.6% of children were identified as dyslexic and suffering from symptoms of dyslexia [2]. They need a proper intervention and parents’ support in order to improve their learning ability.

The main objective of this project is to create a mobile application that provides evaluation on children’s cognitive abilities, offers training exercises, and collect data from them, also to create a web application for data analysis. As research shows that the earlier intervention the dyslexic children receive, the better the improvement to be achieved [3]. Therefore, the target users of the mobile application are preschool to kindergarten children. For the web application, there are two types of target users, which are researchers and parents. Researcher can view all the children’s performance and statistics, while parents can only view their own child’s game records.

Dyslexic children are generally weaker in phonological awareness, processing speed, orthographic awareness, working memory and memory span [4], five corresponding game exercises are designed for assessing and improving their abilities before they attend the primary school. By using the concept of open crowdsourcing, the weaknesses of dyslexic children will be analyzed from the game results.

Currently, the project has passed through the Inception and Elaboration phase and undergoing the Construction phase. The mobile application and web application have been implemented and tested. All the data from the mobile application can be successfully collected and presented on the web application.
Acknowledgement

I would like to thank my groupmate, David, for his continuous dedication to this project. I would also like to express my greatest gratitude towards our supervisor Dr. T. W. Chim, for his support, advice and encouragement. Last but not least, I would 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.
1 Table of Contents

Summary .................................................................................................................. 2
Acknowledgement ................................................................................................... 3
List of Figures ........................................................................................................... 5
List of Tables ............................................................................................................ 7
List of Abbreviations ................................................................................................ 7

1 Background ............................................................................................................ 8
2 Objective ............................................................................................................... 10
3 Previous Works Evaluation .................................................................................... 11

4 System Design ....................................................................................................... 12
  4.1 System Architecture ......................................................................................... 12
  4.2 Methodology ..................................................................................................... 14
    4.2.1 Handwriting Recognition ........................................................................... 14
    4.2.2 Question Generation .................................................................................. 15
    4.2.3 Data Visualization ..................................................................................... 15
  4.3 Development Platform ...................................................................................... 15

5 Game Application Content .................................................................................... 16
  5.1 Game Design ..................................................................................................... 16
  5.2 Parent Panel ....................................................................................................... 17

6 Deliverable ............................................................................................................. 18

7 Work Accomplished ............................................................................................... 19
  7.1 Server and Database Setup ............................................................................... 20
  7.2 Game Application .............................................................................................. 21
    7.2.1 Starting Screen ............................................................................................ 22
    7.2.2 Option Menu ............................................................................................... 23
    7.2.3 First-time Registration ............................................................................... 24
    7.2.4 Story and Tutorial ....................................................................................... 25
    7.2.5 Interactive Menu ......................................................................................... 26
    7.2.6 Shop Menu .................................................................................................. 27
    7.2.7 Processing Speed ........................................................................................ 28
    7.2.8 Phonological Awareness .......................................................................... 30
    7.2.9 Orthographic Awareness ......................................................................... 32
    7.2.10 Working Memory ...................................................................................... 35
    7.2.11 Memory Span ........................................................................................... 37
    7.2.12 End Game .................................................................................................. 39
    7.2.13 Parent Panel ............................................................................................... 40
FYP16012 – Open Crowdsourcing

7.3 Web Analytics Dashboard ................................................................. 41
  7.3.1 Login and Registration ............................................................... 41
  7.3.2 Web Analytics Dashboard for Researchers ................................. 42
  7.3.3 Orthographic Awareness Analysis for Researchers .................. 44
  7.3.4 Web Analytics Dashboard for Parents ...................................... 46

8 Difficulties/limitation Encountered .................................................. 47

9 Future Development ........................................................................ 48
  9.1 Question Customization ............................................................... 48
  9.2 Sorting ....................................................................................... 48
  9.3 Changing Education Level .......................................................... 48
  9.4 Cantonese Support .................................................................... 48

10 Conclusion .................................................................................... 49

11 References ................................................................................... 50

12 Appendices .................................................................................... 51
  12.1 Appendix I: Flow chart of the game application ....................... 51

List of Figures

Figure 1 - System Architecture .................................................................. 12
Figure 2 - Node.js VS PHP Performance .................................................. 13
Figure 3 - MySQL VS MongoDB INSERT .............................................. 14
Figure 4 - MySQL VS MongoDB SELECT .............................................. 14
Figure 5 - Point Alignments for a Spiral Gesture .................................... 14
Figure 6 - Ten Variations of Word "teapot" as Written by Dyslexics .......... 15
Figure 7 - A Radar Chart Showing Children’s Abilities ............................. 17
Figure 8 - Starting Screen Interface ....................................................... 22
Figure 9 - Warning Window .................................................................. 22
Figure 10 - Option Menu Interface ........................................................ 23
Figure 11 - User Registration Interface .................................................. 24
Figure 12 - Parent Account Registration Interface ............................... 24
Figure 13 - Story and Tutorial Interface ................................................ 25
FYP16012 – Open Crowdsourcing

Figure 14 - Interactive Menu Interface ................................................................. 26
Figure 15 - Bonus Coins Reward ......................................................................... 26
Figure 16 Shop Menu Interface .......................................................................... 27
Figure 17 - Processing Speed Instruction Interface ............................................. 28
Figure 18 - Processing Speed Game Interface ....................................................... 28
Figure 19 - Processing Speed Correct and Wrong Effect .................................... 29
Figure 20 - Phonological Awareness Instruction Interface .................................... 30
Figure 21 - Phonological Awareness Game Interface .......................................... 30
Figure 22 - Phonological Awareness Correct and Wrong Effect .......................... 31
Figure 23 - Orthographic Awareness Instruction Interface .................................. 32
Figure 24 - Orthographic Awareness Part 1 Question Interface ............................ 32
Figure 25 - Orthographic Awareness Part 1 Answers Interface ............................ 33
Figure 26 - Orthographic Awareness Part 2 Question Interface ............................ 33
Figure 27 - Orthographic Awareness Part 2 Answer Interface ............................. 34
Figure 28 - Woking Memory Instruction Interface ............................................... 35
Figure 29 - Working Memory Game Interface ..................................................... 35
Figure 30 - Working Memory Three Types of Buttons .......................................... 36
Figure 31 - Working Memory Correct and Wrong Effect ..................................... 36
Figure 32 - Memory Span Instruction Interface .................................................... 37
Figure 33 - Memory Span Game Interface ............................................................ 37
Figure 34 - Memory Span Wrong Effect ............................................................... 38
Figure 35 - End Game Interface ........................................................................... 39
Figure 36 - Warning Message Pops Up for Internet Connection Problem ............ 39
Figure 37 - Parent Panel Interface Page 1 ............................................................. 40
Figure 38 - Parent Panel Interface Page 2 ............................................................. 40
Figure 39 - Account Login Interface ................................................................... 41
Figure 40 - Account Registration Interface .......................................................... 41
List of Tables

Table 1 - Game Content ........................................................................................................16
Table 2 - Deliverable .............................................................................................................18
Table 3 - Work Accomplished ...............................................................................................19
Table 4 - Difficulties/limitation encountered ........................................................................47

List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</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 traditional Chinese thought, the children who learn, write and read slowly are always being branded as “lazy”. However, there are many possibilities that could lead to troubles with learning. One of the common possibilities is dyslexia. Dyslexia is one of the Specific Learning Difficulties (SpLDs). Children with dyslexia not only have difficulties in reading and writing, but also have difficulties in pronouncing multisyllabic words and distinguishing words with similar sounds [4]. Most of the people are unfamiliar with dyslexia, or they neglect the importance of intervention. They might not consider bringing their children to have a formal screening test. Even they wanted to, the screening test may cost several thousand Hong Kong dollars which are not affordable to lower-income families. Therefore, a simple, free-of-charge, easy-to-use application is necessary for testing their children and alert the parents for signs and symptoms of dyslexia in advance.

According to research by Foorman, Francis, Shaywitz, Shaywitz, and Fletcher (1997), for the children with SpLDs and receive intervention in lower primary school, the success rate is 82%. For third grade to fifth grade children, the success rate is 46% but for the higher grade student, the success rate drops to 10%-15% [3]. The research concludes that it is better to notice children’s learning difficulties and receive intervention as early as possible. However, one of the biggest problems is that it is difficult for the parents to observe the learning problem of their preschool to kindergarten children because they are not required to spell and write very often. As they do not have much homework, they are more likely to learn during school rather than at home. Also, class teachers may not be able to identify the student with specific learning difficulties among a large group of students.

In this project, a new set of training games will be designed for preschool to kindergarten children. It will be a user-friendly application for children and parents. The application can evaluate the children’s performance in different abilities. The difficulty of the training games depends on their educational level. Improvement will be shown if the dyslexic children complete the game sessions regularly. Even though the children may not know how to read and write, there are certain methods to test their abilities. For example, although preschool children have not learned alphabetic letters yet, their orthographic awareness could still be assessed by treating the letters such as “p” and “q” as an image or giving them the actual pictures. There will be no pass-fail line or specific standard to diagnosing dyslexia in children. However, with the crowdsourcing features, it should be able to analyze their level by comparing a large group of children in same age. They could easily find out their strengths and weaknesses in different abilities. The best result of the application will be that the children can achieve significant improvement by playing the games continuously and can study normally without consulting the therapy. However, parent can still decide to bring their children to a formal assessment if their performance is generally weaker than same-age children.

The web analytics dashboard is part of this project. It provides interactive charts on gender, education level distribution and the average score on individual game. It makes the analysis of the game exercises and children’s performance easier and more efficient.
For the long term, after collecting sufficient data, it should be able to discover the weakest abilities of the dyslexic children in Hong Kong and find the most effective training method to help them. The collected data could also help researchers to design a better assessment method by analyzing the incorrect answers from the children.

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

There are several objectives to be achieved:

1. **To develop a mobile application for improving children’s cognitive abilities**
   The application offers five games with three difficulties. Each game is designed for assessing a single cognitive ability. The five abilities are processing speed, phonological awareness, orthographic awareness, working memory and memory span. By overlearning, children’s abilities on these five areas will be improved.

2. **To develop a web analytics dashboard for data visualization and management**
   The web analytics dashboard generates interactive charts by using data visualization. Researchers and parents can view children’s performance and improvement in the game exercises. Researchers can also manage the test data collected from the orthographic awareness game. Those data show the children performance in writing and alphabets recognition skills.

3. **To facilitate parent-children interactions**
   Parents are the key roles in successful early childhood intervention. Parent Panel in the application allows parents to monitor children’s game records and compare their performance with other same education level peers. With the Parent Panel and Web analytics dashboard, they can easily understand their children’s situation and provide supports to them.

4. **To provide analysed data for investigating symptoms of dyslexia**
   The collected data helps researcher to discover the weakest abilities of the dyslexic children and find the most effective training methods to help them. Analyzing a large amount of sample of incorrect answers would allow the researchers to define a better assessment method for dyslexia. It also raises the awareness of dyslexia with the widespread of the application.
3 Previous Works Evaluation

There are some previous works created for helping the children with dyslexia or other special educational needs:

- **Eye Games [5]**
  It is an Android application that provides many matching games for improving the children’s visual perception. They will learn to make connections pictures, letters, shapes and backgrounds. However, there is only a single game mode, which is to select the identical objects. The children may easily get bored.

- **Galaxy Maze [6]**
  It is an Android application of ball rolling game for improving the children’s memory. Children need to roll the ball to finish the maze. Parents can be able to adjust the game difficulty and starting point of the maze. The idea of parent involvement is good but the variety of the game level is not large enough. Also, the interface could be more colorful.

- **Dyslexia Quest [7]**
  It is an iOS application that provides six different games for testing memory and learning skills. The interface is nice and it provides information about the user’s’ strengths and weakness. The overall idea and game design are nice but the application is not designed for preschool and kindergarten children.

The project group identified several advantages and disadvantage among above previous works. These are the general disadvantage in the previous works that should be avoided:

I. Unattractive interface
II. Few game modes
III. Repeated game contents

Also, these are the advantages that could be integrated into this project:

I. Parent’s involvement
II. Children’s performance analysis

It is important to attract the children to continuously play with the games and not to get bored easily, otherwise the improvement will not be significant. Especially the target group of this project are the preschool to kindergarten children, they need colorful interface and fun music. Overlearning is good for dyslexic children but the repeated game contents should be avoided. Therefore, it is decided to enlarge the dataset for game contents and make use of random generation.

Children’s performance analysis is one of the key elements in this project. It is because the parents need to know their strengths and weaknesses in order to determine whether the children have trouble in learning. It is also necessary to find out the improvement they made for the project group to evaluate the effectiveness of the game exercises.
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:

I. 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.

II. 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.

III. 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.

IV. 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?

Node.js is not the only way to implement the client-server architecture. Another common method is using PHP with MySQL. PHP is widely used and easy to learn. Node.js is a low-level technology, so it is complicated than PHP. However, Node.js is using an event-driven and non-blocking I/O architecture which is able to handle concurrent requests. If the application requires a lot of I/O requests, Node.js will be faster. To test the performance of Node.js and PHP, the response times for handling 200 HTTP requests were recorded (Figure 2) [9]. Node.js took 175.535 seconds to respond all the requests and PHP took 711.790 seconds. Node.js was four times faster than PHP when handling many concurrent requests. Since this project requires to implement the crowdsourcing process, a high performance approach is needed for data collection and analysis. Therefore, Node.js is more suitable for this project.

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

**FIGURE 2 - NODE.JS VS PHP PERFORMANCE**

Besides the server scripting language, the choice of database system can also affect the performance. Node.js and PHP are usually connected with different database systems. MySQL is the most popular relational database used with PHP. On the other hand, Node.js is natural with NoSQL databases such as MongoDB. Therefore, MySQL was also compared with MongoDB. The performances of MySQL and MongoDB were tested by handling multiple INSERT and SELECT queries, which are the most common queries that will be used in this project. The response times for handling 10000 INSERT queries are shown in figure 3 [10]. The response time of MySQL was 440 seconds and MongoDB was 0.29 seconds. For testing the performance of SELECT query, 10000 users and 5000 discussion topics where previously inserted. There were two SELECT queries tested, the first one is to select all discussion a user attended, and the second one is to select all users and the number of discussion started by each user [10]. The result is shown in figure 4 [10]. For the first query, the computation was simple and the response times were nearly the same. For the second query, the computation was much more complicated than the first query. The response time of MySQL was 0.6478 seconds and MongoDB was 0.0052. Therefore, no matter handling INSERT or SELECT queries, MongoDB had a better performance than MySQL.

MySQL and MongoDB are usually used in different situations. MySQL is better than MongoDB when the application involves complex transactions, such as bank account transfer and reservation system.
MongoDB is better than MySQL when it involves rich data model and dynamic schema. As it has a higher flexibility and scalability, it is suitable for handling data analysis.

![Figure 3 - MySQL VS MongoDB Insert](image1)

![Figure 4 - MySQL VS MongoDB Select](image2)

After comparing PHP with Node.js and MySQL with MongoDB, it is decided to use Node.js with MongoDB as the server model in this project for the following reasons:

I. Higher flexibility

II. Higher scalability

III. Higher performance when processing big data

4.2 Methodology

4.2.1 Handwriting Recognition

The SP Point-Cloud Recognizer is used in this project for recognizing user handwriting. It is a 2-D gesture recognizer for gesture-based user interface [11]. It represents and recognizes users’ stroke gestures as point clouds (figure 5). An advantage of this algorithm is that the number of strokes, stroke ordering and stroke directions are irrelevant in recognizing gestures, which is very suitable for this project as the only corner of this project is the outline of user handwriting.

![Figure 5 - Point Alignments for a Spiral Gesture](image3)
4.2.2 Question Generation

Dyslexic children have trouble in processing words and graphics. The orientation and mirroring problem always happen to them when they try to read [12]. For example, they may get confused with “q” and “d”, “pool” and “loop” [13]. In the writing part of the orthographic awareness game, the children may write a wrong answer due to this problem (figure 6). Both correct and wrong answers will be collected for generating alphabet recognition mc questions, as those wrong answers would best represent the common mistakes happens in children with dyslexia. As the data set will expend every time a user play this game, there will be a huge variety in the game. It produces flexible game content and unique game experience to users.

4.2.3 Data Visualization

Data Visualization is implemented on the web analytics dashboard. D3.js is the main tool used for render graphical objects on a web page. It is a JavaScript library that applies data-driven transformations to the document. Those documents are fetched from MongoDB. Crossfilter and dc.js are also acted as the key libraries for making the interactive charts. Crossfilter provides an extremely fast way to manipulate data. Dc.js supports 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.

4.3 Development Platform

The Node.js server, database and web application are hosted in a Virtual Private Server (VPS) provided by DigitalOcean. The operating system of the VPS is Ubuntu LTS 14.04. Express framework is used for developing the web analytics dashboard.

Unity is the main development platform used in the game application. It supports cross-platform game development for Android, iOS, Windows, Linux, etc. It also supports C# and JavaScript programming languages. Unity Community provides a lot of assets and tutorials which are a good reference for the project. Testing platforms of the application is an iPad Air 2 with iOS 10.3.1.
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. Users need to enter the children’s name, gender and education level, they also need to create a parent account for accessing parent panel before the application is functional.

5.1 Game Design

The difficulties of the games exercise will be determined based on their education level and it will be divided into three stages: Beginner(preschool), Intermediate(K1-K2) and Advanced(K3). It includes 5 game exercise and each game corresponds to one specific category of weak abilities. All the questions in each category are randomly generated. The children will be required to play all the games once before they can freely play the game exercise. As the target users are young, they may not be able to fully understand the written instructions of the games. Therefore, the games will involve verbal instructions. A text-to-speech (TTS) extension will be used for generating voice dialogue. The details of the game exercise are as follow (Table 1):

**Table 1 - Game Content**

<table>
<thead>
<tr>
<th>Category</th>
<th>Meaning</th>
<th>Beginner(preschool)</th>
<th>Intermediate (K1-K2)</th>
<th>Advanced (K3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phonological awareness</td>
<td>the ability to manipulate meaningful sounds in human languages</td>
<td>Word Discrimination: identify whether two words are the same or different</td>
<td>Rhyme Recognition: identify whether two words end the same or rhyme</td>
<td>Word Discrimination and Rhyme Recognition: identify whether two words are same, different or rhyme</td>
</tr>
<tr>
<td>Processing speed</td>
<td>the ability to solve problems or tasks quickly</td>
<td>Visual Scanning Task: 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 quick as he/she can</td>
<td>Visual Scanning Task: 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 quick as he/she can</td>
<td>Visual Scanning Task: 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 quick as he/she can</td>
</tr>
<tr>
<td>Orthographic awareness</td>
<td>the ability to form, store and recall</td>
<td>Writing the Alphabets and Recognizing Letters: ask the user to write</td>
<td>Writing the Alphabets and Recognizing Letters: ask the</td>
<td>Writing the Alphabets and Recognizing Letters: ask the</td>
</tr>
</tbody>
</table>
words | the alphabet, showing words with length two to four and with similar appearance and ask the user to pick the correct one | user to write the alphabet, showing words with length three to five and with similar appearance and ask the user to pick the correct one | the alphabet, showing words with length four to six and with similar appearance and ask the user to pick the correct one
---|---|---|---
**Working memory** | the ability to remember and transform the information at the same time | Message Transformation: two to three digits/alphabets/symbols will be presented in sequence and ask the user to recall them in reverse order | Message Transformation: two to four digits/alphabets/symbols will be presented in sequence and ask the user to recall them in reverse order | Message Transformation: two to five digits/alphabets/symbols will be presented in sequence and ask the user to recall them in reverse order
**Memory span** | the ability to receive the verbal information and repeat it in sequence | Span Task: present two to three numbers/alphabets verbally and ask the user to recall them in sequence | Span Task: present two to four numbers/alphabets verbally and ask the user to recall them in sequence | Span Task: present two to five numbers/alphabets verbally and ask the user to recall them in sequence

5.2 Parent Panel

The parent panel is specially made for the parents to view their children’s performance in the game exercise. After completing the game exercise, the application would find out the strengths and weaknesses of the children and shown in the parent panel. Also, the results will be 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 in a radar chart easily (figure 7). If the score is significantly below average, the parent may consider taking further actions.

![Figure 7 - A Radar Chart Showing Children’s Abilities](image)
The deliverables of this project are shown below.

**TABLE 2 - DELIVERABLE**

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

The final tested implementation of this project has been done. In this section, details of the work accomplished will be shown.

**Table 3 - Work Accomplished**

<table>
<thead>
<tr>
<th>Date</th>
<th>Work Accomplished</th>
<th>Assigned to</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 2016</td>
<td>Research on dyslexia, previous works and feasibility</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>Project Website</td>
<td>All</td>
</tr>
<tr>
<td>November 2016</td>
<td>Prototype</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>Server and Database Setup</td>
<td>David Chan</td>
</tr>
<tr>
<td>December 2016</td>
<td>Game Application</td>
<td></td>
</tr>
<tr>
<td></td>
<td>First-time registration</td>
<td>David Chan</td>
</tr>
<tr>
<td></td>
<td>Interactive Menu</td>
<td>Enid Lam</td>
</tr>
<tr>
<td></td>
<td>Processing Speed</td>
<td>Enid Lam</td>
</tr>
<tr>
<td></td>
<td>Web Analytics Dashboard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Data Visualization</td>
<td>All</td>
</tr>
<tr>
<td>January 2017</td>
<td>Game Application</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Phonological Awareness</td>
<td>Enid Lam</td>
</tr>
<tr>
<td></td>
<td>Orthographic Awareness</td>
<td>David Chan</td>
</tr>
<tr>
<td></td>
<td>Parent Panel</td>
<td>Enid Lam</td>
</tr>
<tr>
<td>February 2017</td>
<td>Memory Span</td>
<td>Enid Lam</td>
</tr>
<tr>
<td></td>
<td>Working Memory</td>
<td>David Chan</td>
</tr>
<tr>
<td></td>
<td>Option Menu</td>
<td>Enid Lam</td>
</tr>
<tr>
<td></td>
<td>Shop Menu</td>
<td>Enid Lam</td>
</tr>
<tr>
<td></td>
<td>Background music and sound effect</td>
<td>ALL</td>
</tr>
<tr>
<td></td>
<td>Web Analytics Dashboard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Login System</td>
<td>Enid Lam</td>
</tr>
<tr>
<td></td>
<td>Orthographic Awareness Analysis</td>
<td>David Chan</td>
</tr>
<tr>
<td>March 2017</td>
<td>UI Optimization</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>Testing</td>
<td>All</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 modeling package for Node.js.

The schemas of the data are defined as follow:

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

var userSchema = new mongoose.Schema({
    uid: {type: String, trim: true},
    name: {type: String, trim: true},
    gender: {type: Number, min: 0},
    eduLv: {type: Number, min: 0},
    dateCreated: {type: String},
    proSpd: [gameSchema],
    phono: [gameSchema],
    ortho: [gameSchema],
    workMem: [gameSchema],
    memSpan: [gameSchema]
});

var letterSchema = new mongoose.Schema({
    png: { data: Buffer, contentType: String },
    noOfPlay: {type: Number, min: 0},
    noOfChosen: {type: Number, min: 0},
    status: {type: Number, min: 0},
    dateCreated: {type: String}
});
```
var orthoSchema = new mongoose.Schema({
  letter: {type: String},
  image: [letterSchema],
  correctWrite: {type: Number, min: 0},
  totalWrite: {type: Number, min: 0},
});

var phonoSchema = new mongoose.Schema({
  rhymeWords: {type: Array},
});

var dictionarySchema = new mongoose.Schema({
  words: {type: String}
});

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.

7.2 Game Application

There are total five games in the game application. The game story and every game instruction will be presented by text and text-to-speech function.
7.2.1 Starting Screen

Figure 8 - Starting Screen Interface

Figure 9 - Warning Window
The figure 8 show the starting screen interface. There are a start button, option button and a clear game data button. After the user presses the start button, the application will check whether the local game data is stored in the device. If no data is found, the user has to perform first-time registration (see 7.2.3. first-time registration). Otherwise, the user can continue their game in the interactive menu (see 7.2.4. interactive menu). If the user presses the option button, an option window will pop up. (see 7.2.2. Option menu). When the user presses the clear game data button, a warning window (figure 9) will pop up and ask for user confirmation.

7.2.2 Option Menu

![Option Menu](image)

**Figure 10 - Option Menu Interface**

The option menu allows user to adjust the global volume, music volume and sound volume. There are three buttons on the menu. The left button is for accessing the parent panel (see 7.2.13 parent panel). This button is not intractable if the user account has not been created. The middle button is for going back to the home page. The right button is to continue the game.
### 7.2.3 First-time Registration

**Figure 11 - User Registration Interface**

**Figure 12 - Parent Account Registration Interface**
Figure 11 shows the user registration interface. It is designed with a simple, user-friendly and colourful layout. The name field requires the user to input the name by an on-screen keyboard. The education field requires the user to drag the indicator on the slide bar. The gender can be chosen by clicking the “Male” or “Female” button and the selected button will become disabled. After inputted all the required information, the user needs to click on the arrow button. When the arrow button is clicked, the user needs to process on creating the parent account registration.

In the parent account registration interface (figure 12), the parent needs to input his/her username, password and confirm password. After the submit button is clicked, three conditions will be checked by the application: 1. application and the server is successfully connected, 2. Username is unique, 3. Password is equal to confirm password. If three conditions are fulfilled, the user information will be passed to the server and stored in the database. Also, the story of the game will be shown to the user (see 7.2.4 Story). Otherwise, corresponding warning message will be shown to the user.

7.2.4 Story and Tutorial

![Story and Tutorial Interface](image-url)
The figure above shows the interface of the story and tutorial. The application makes use of text, text-to-speech function and animation to present the story and tutorial to the user. The story and tutorial will only be shown once, after the first-time registration. Users are allowed to skip the story and tutorial by clicking the “SKIP” button on the top-right corner.

7.2.5 Interactive Menu

![Interactive Menu Interface]

![Bonus Coins Reward]

In order to make the application more attractive and interesting, the game selection menu is designed to be interactive (figure 14). The user can walk around by pressing the left and right arrow, or even jump by pressing the up arrow button. The shop button is used for accessing the shop (see 7.2.6 Shop Menu). On the top-left corner, there is an item list. The items can be collected by
finishing the corresponding game. If the user successfully collected five items, there will be 100 bonus coins added to user’s wallet for rewarding (figure 15). Then, the item list will reset to zero and this reward can be earned multiple times, which aims to encourage the user to finish all the games again and again. The fire button is used for entering the game. When the character arrived the game selection points, the fire button will become active. The key button is used for unlocking the doors. Again, when the character arrived the front of the door, the key button will become active.

Noted that, on the first-time play, the user must finish the five games in sequence. After that, they can randomly choose the game they want to play. The reason for this is to ensure they go through all the games at least once to find out their strengths and weaknesses, then they can improve their weaknesses by replaying the certain games.

7.2.6 Shop Menu

The shop menu allows users to buy characters or change current character. If the user’s coins are lower than the price, the “+” button will become not intractable. The bought character will show a “USE” button instead of “+” button, which is for users to change current character. The reason for creating a shop menu is to encourage children to play more game exercises and get rewards by buying new characters. If they want to collect all the characters, they need to at least play 19 times for each game.
7.2.7 Processing Speed

**Figure 17 - Processing Speed Instruction Interface**

**Figure 18 - Processing Speed Game Interface**
Figure 18 shows the advanced level interface of the processing speed game. It starts with showing the instruction of the game (figure 17). It tests the users by giving them visual scanning task. The objects on the screen have similar shapes or colours. The game requires the user complete the task within certain time. On the top, it displays a countdown timer. The game will end when the time is up. The task is showing on the thinking bubble on the bottom-left corner. Users need to drag the correct item into the bag and the correct or wrong effects will be shown (figure 19).

The full score of the game is 100. Each correct answer worth 5 scores. The final score will be the basic score multiplies by accuracy.
7.2.8 Phonological Awareness

**Figure 20 - Phonological Awareness Instruction Interface**

**Figure 21 - Phonological Awareness Game Interface**
Figure 20 shows the advanced level interface of the phonological awareness game. It starts with showing the instruction of the game (figure 19). It tests the users by producing sounds of two words, and ask users to identify the relationship between two words. Users need to click on the bubble on the bottom and the correct or wrong effects will be shown (figure 19).

The full score of the game is 100. Each correct answer worth 10 scores. There are total 10 questions.
7.2.9 Orthographic Awareness

**Figure 23 - Orthographic Awareness Instruction Interface**

**Figure 24 - Orthographic Awareness Part 1 Question Interface**
Figure 25 - Orthographic Awareness Part 1 Answers Interface

Figure 26 - Orthographic Awareness Part 2 Question Interface
The figures above show the advanced level interface of the orthographic awareness game. It starts with showing the instruction of the game (figure 23). It tests the users by giving them two types of tasks.

For the first part, the question board will show a word for a second, then the users need to select the correctly written answer. They can view the question again by holding the “?” button.

For the second part, the question board will show an alphabet letter for a second, then the users need to write the alphabet correctly. They can view the alphabet again by holding the “?” button. They can clear the writing area by clicking the garbage bin button. And they need to submit the answer by clicking the tick button.

The full score of the game is 100. Each correct answer worth 10 scores. There are total 10 questions.
7.2.10 Working Memory

Figure 28 - Working Memory Instruction Interface

Figure 29 - Working Memory Game Interface
The figures above show the advanced level interface of the working memory game. It starts with showing the instruction of the game (figure 28). It tests the users by showing the numbers/alphabets/symbols one by one, and ask the users to press them in reverse order. After they pressed the button, the correct or wrong effects will appear (figure 31).

The full score of the game is 100. Each correct answer worth 10 scores. There are total 10 questions.
7.2.11 Memory Span

**Figure 32 - Memory Span Instruction Interface**

**Figure 33 - Memory Span Game Interface**
The figures above show the advanced level interface of the memory span game. It starts with showing the instruction of the game (figure 32). It tests the users by presenting the numbers/alphabets one by one verbally, and ask the users to press them in order. After they pressed the sequence, wrong effects will appear if the answer is wrong (figure 34).

The full score of the game is 100. Each correct answer worth 10 scores. There are total 10 questions.
After the users finish a game, an end game interface will be shown (figure 35). The number of stars represents the scores of the result. If they got more than or equal to 90 scores, they will get three stars. If they got more than or equal to 60 scores, they will get two stars. Otherwise, one star will be given. Each star worth 10 coins. After they pressed the “EXIT” button, the game result will be uploaded to the database. However, if the connection between the server and the application has not been set up, the warning window will pop up (figure 35). The users can decide whether to try again after checking the internet connection, or to discard the game record.
7.2.13 Parent Panel

**Figure 37 - Parent Panel Interface Page 1**

**Figure 38 - Parent Panel Interface Page 2**
After entering the parent account password correctly, the parent panel interface will be shown (figure 37). On the left-hand side, it displays a radar chart showing the average scores of the five games. The pentagon in blue represents the current user’s average scores for each game. The pentagon in green represents the average scores of all children having the same education level with the current user. On the right-hand side, it shows the actual value of the average scores.

When the users press the right arrow button, it will turn into next page (figure 38). It refers the parents to the web analytics dashboard for detail performance charts (see 7.3.4 Web Analytics Dashboard for Parents).

If the users pressed the left arrow button, it will turn to the previous page.

7.3 Web Analytics Dashboard
7.3.1 Login and Registration

There are two types of users for the web analytics dashboard, researchers and parents. For parents, they can login by using their parent account (see 7.2.3 First-time Registration). For researchers, they
can register their account on the web (figure 40). Both users share the same login page (figure 39). After logging in, the web application will render the page based on their user type.

### 7.3.2 Web Analytics Dashboard for Researchers

The web analytics dashboard for researchers has two main functions:

1. Game records and statistics (Data Visualization)
2. Orthographic Awareness Analysis

For the second function, please see 7.3.3 Orthographic Awareness Analysis for Researchers.

For the first function, the interface contains 8 charts (figure 41):

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 analyze the performance of K3 male users created in April 2017, then they can select April on chart 1, “K3” on chart 2 and select “male” on chart 3. The result is shown in Figure 42.

**Figure 42 - Result of Selecting "K3" and "Male" Users Created in April 2017**

The non-selected regions will be changed into grey colour. The data on the other charts will change instantly which match with the selected groups. From the above example, it shows that there are total 15 players in the selected groups with total 48 games played by them. The improvement on Orthographic Awareness (Chart 6) is not significant. The expected result would be the more they play the higher the average score they get, just like the Processing Speed chart (Chart 4) in the example.
Orthographic Awareness Analysis for Researchers

This page is showing the data collected from the Orthographic Awareness game.

There are total seven columns:

1. Image: The .png image collected from the writing tasks in orthographic awareness game
2. Name: The name of the png file
3. Character: The actual character represented by this image
4. Correctness (figure 46): Whether the image is correctly written and matches the character field
5. Status (figure 45):
   a. Idle: Not using in the recognizing word tasks yet, it is also the default status when it is uploaded from the writing tasks.
   b. In Use: Currently using for generating multiple choices in the recognizing word tasks
   c. Finished: For images that have been collected sufficient data for wrong rate calculation. It will not be used in the games again.
6. Wrong Rate (only applicable to the wrong images): The wrong rate from the recognizing word tasks in the orthographic awareness game. It is calculated by the number of time chosen by the children divided by the number of time appear as multiple choices in the game
7. Select: To select images for changing their status or correctness

The drop-down lists in the top-left corner is used for changing the displayed contents (figure 45). The users can view the contents based on the alphabet images status, correctness and character.
Open Crowdsourcing

The drop-down lists in the top-right corner is used for changing the status or correctness of the selected images (figure 46). For example, if the user want to view all the wrong images written by the users and currently using for the MC questions, the result is shown below (figure 44).

**Figure 44 - Result of Selecting All Wrong Alphabets with Status "In Use"**

**Figure 45 - Drop Down List for Status**

**Figure 46 - Drop Down List for Correctness**
7.3.4 Web Analytics Dashboard for Parents

If users logged in as parents, they can view their own children’s game records (figure 47). They can easily discover the strengths, weaknesses and improvement in different abilities. In above example, it shows that there is a huge improvement on the Processing Speed ability.

**Figure 47 - Dashboard Interface for Parents**
8 Difficulties/limitation Encountered

The difficulties/limitation encountered in this project are shown below.

<table>
<thead>
<tr>
<th>Difficulties/limitation</th>
<th>Impact</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<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 involved in the mobile application. If the team decides to develop too many games, the team may not be able to finish it within the period of final year project</td>
<td>Low</td>
<td>Five mini games were decided because each game tests each of the five weak abilities of dyslexic children. They cannot be joined together because it affects the result of assessment or training. In order to ensure the progress of the game exercise, each game exercise would be in form of mini games to reduce the time of development.</td>
</tr>
<tr>
<td>Inconvenient in cooperating with a Unity project between members</td>
<td>Low</td>
<td>After discovering the problem, the team found that there is 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 Future Development

While this project is useful for testing student abilities and get understanding towards dyslexia, there are several possible improvements can be done in the future to further increase the flexibility, efficiency and effectiveness for research.

9.1 Question Customization
It would be better if the researchers can customize the questions in the games on the web interface. For example, they may customize the symbols showing on the buttons in the working memory game, or they may change the items showing in the processing speed game. Those customizations could also affect children’s performance in the games. Therefore, with this feature, they can assess the children with different variables and find out the most effective methods to help them.

9.2 Sorting
For the researchers to find out the most common mistakes happens on children, it would be better if the web application provides sorting method based on the wrong rate.

9.3 Changing Education Level
The game difficulties are depending on users’ education level. In the current version, if the users go up one grade in school, they must create a new account for playing the games with higher difficulties. Otherwise, the collected data will remain on the old education level and may affect the accuracy of the data analysis.

9.4 Cantonese Support
As Children in Hong Kong may not native in English, they may have a relatively poor performance and causes false sign of dyslexia. Therefore, the application would become more useful for Hong Kong Children if it supports Cantonese.
10 Conclusion

This project offers game exercises for children, especially for those who have dyslexia, to improve their cognitive abilities before they attend primary school. It is hoped that for dyslexic children, by using the application, their parents can spot the sign of dyslexia as soon as possible and support them to go through the early intervention. So that the parent-child interaction could be facilitated.

This project also provides an important platform for researchers and parents, which is the web analytics dashboard. With data visualization, it makes the analysis process on children performance and game exercises effectiveness much more easy and efficient. For researchers, they could change the test images for recognizing words exercises, to find out the shapes of the characters that they have trouble to distinguish them.

To summarize the report, the mobile application and web application have been implemented and tested. It is hoped that related organizations or research groups could provide advice and supports in optimizing the effectiveness of the applications, and thus raises awareness of dyslexia.
11 References


12 Appendices

12.1 Appendix I: Flow chart of the game application

Flow chart of the application:

**Figure 48 - Flow chart of the Game Application**