MathFun: A Mobile App For Dyscalculia Children

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Abstract. Learning disability can vary from dyslexia (reading), dyscalculia (math) and dysgraphia (writing) where it focuses on certain learning disability that is being faced by the children. Dyscalculia is one of the common learning disabilities where in this category children are lack in ability of studying the math. However, with the enhancement of technologies, variety of application can be created in aiding the children learning process such as mobile learning by using mobile app. This paper focuses on the findings from the result of the MathFun app on the effectiveness towards enhancing the learning process for the learning disability children. MathFun is a mobile app created by following the Calculic Model approach for Malaysia Dyscalculia children. Usability was performed in order to assess the usability and verifying the effectiveness of MathFun. This study involved 3 teachers and three children. Descriptive analysis was performed from the collected data. Based on the outcome, it’s shows that the MathFun app able to help and improve the learning and has the potential to be use in the classrooms.

Keywords. Dyscalculia, Learning Difficulties, Mobile Application, MathFun, Usability

1. Introduction
Children with dyscalculia learning issues will definitely have some trouble with a lot of aspects of math. For example, they will not have the ability to understand the notion of biggest against smallest. Moreover, they will also have the limitation of understanding that the numeral 5 is actually the same meaning as the word Five. Working memory is also one of the issues that dyscalculia children will confront. For instance, they will have arduous in holding numbers in mind while executing mathematics functions with several steps. Eventually, they will confront the problem of having difficulty in applying mathematical function when they are solving math problems. Therefore, children with dyscalculia or can be called as mathematics learning disability will definitely have issues with numbers. If it gets critical, dyscalculia may also affect everyday skills such as social interactions skill and time management skill.

However, the good news is that mobile learning capabilities are widely used in aiding special educational practices for children. Therefore, these mobile applications can eventually help in educating and supporting children that have learning disabilities in fundamental abilities of writing, reading as well as mathematics. Therefore, Dyscalculia children should utilize the mobile application as the supporting learning methods or tools in order to support and educating their learning regarding the fundamental mathematics. In this way, children with have the benefit in learning the fundamental math not only during study in school but in home too as mobile application has the graphic and
patterns which can greatly help them to stimulate the brain effectively to learn math which strengthen their fundamental skills in mathematics.

2. Literature Review
Dyscalculia is a form of learning disability where it is caused by visual perception deficit where children are unable to recognize and performing mathematic operations. Based on the research done by (Plerou, 2014), Dyscalculia is the disability of comprehending as well as solving mathematical concepts which consist of fundamental numbers, the name of the numbers, comparing with bigger and smaller number, the number sequence as well as the operations of mathematics. According to (Ferraz & Neves, 2015), they proposed that children with dyscalculia usually distribute into six types, which shows in Table 1.

| Types of Dyscalculia     | Description                                                                 |
|--------------------------|-----------------------------------------------------------------------------|
| Lexical Dyscalculia      | Having troubles in reading mathematical symbols such as operational signs $+,-,\times,\div$ and other numeral numbers. |
| Verbal Dyscalculia       | Having troubles in the name of mathematical symbols and concepts, which will be able to read but unable to talk, remember or even recognize them. |
| Graphic Dyscalculia      | Having troubles in writing the mathematical symbols.                          |
| Operational Dyscalculia  | Having troubles in performing the mathematical operations and calculations.   |
| Practognostic Dyscalculia| Having troubles in manipulating things mathematically as well as comparing objects and pictures. |
| Ideagnostic Dyscalculia  | Having troubles in regarding of the mental operations as well as the concepts of mathematics. |

Table 1. Types of Dyscalculia

Dyscalculia can be detected as early as preschool and the symptom can be very visible, as the children get older. Table 2 elaborate in details the characteristics of Dyscalculia children where in this paper it’s more focusing on the children age 4 – 6 years old [2]. By understanding this characteristic more usable interface and interaction will be made available in the designing any applications.

| Age         | Characteristics                                                                 |
|-------------|---------------------------------------------------------------------------------|
| 4 – 6 years old | • Having trouble in learning basic number operations                              |
|             | • Difficulties in memorizing the sequence of number                              |
|             | • Hard to compare or determine the smaller and bigger number                      |
|             | • Counting objects is difficult for them                                         |
|             | • Connecting numbers to the symbolic form is rather difficult for them            |
|             | • Not able to differentiate whether which objects are bigger or smaller           |

Table 2. Characteristic of dyscalculia children based on age

2.1. Technology for Dyscalculia Children
Assistive technologies are technology, which can help dyscalculia children with the compensatory support which to help student to be able to solve mathematical equations easily. Therefore, any technology from paper-based to electronic devices, which can help dyscalculia children are all described as assistive technology. Based on the research paper done by (Rajkumar & Hema, 2016), there are few others assistive technology tools for dyscalculia children, which can help dyscalculia children and is relevant to the proposed system.

Some of the assistive technology that is currently being implemented by a lot of learning center or academic institution is by using the Graph Paper. Graph paper is also one of the learning methods, which helps children with dyscalculia to line up numbers for solving multiple digits equation. Which has the advantage to convenient students to line up numbers in mathematical problems. Besides, author Nagavalli mentioned another assistive technology, which is imperative for the dyscalculia children, is the electronic math worksheets. The electronic math worksheets has the functionality on replacing the traditional paper worksheets which improve the efficiency whereby providing the immediate feedback as well as homework for the dyscalculia children. Another existing system, which is widely being used for helping dyscalculia children, is the talking calculators. Both of the author (Nagavalli & Juliet, 2015) and (Rajkumar & Hema, 2016) proposed that talking calculator is a electronic device which uses voice output to inform the children on identifying any output errors or any keys are being pressed. The calculators will provide the answer to the children out loud, which ensuring the children can help the numbers correctly. Which taking calculators are considered as one of the assistive technologies that are currently being used by a lot of learning center to help the dyscalculia children.

2.2. Existing mobile apps for learning disabilities

Table 3 illustrates the existing mobile apps, which are design to cater the needs of dyscalculia children. One of the mobile apps, which is Calculic Kids apps are designed specially for children in Malaysia.

| Application Name | Operating System | Language | Brief Description |
|------------------|-------------------|----------|-------------------|
| Meister Cody- Talasia | IOS/Android | English | Consists of core markers, number processing, calculation and working memory. |
| Photomath | IOS/Android | English | Consists of step-by-step explanation, animated instruction as well as smart calculator and graphs. |
| Calculic Kids | Android | Malay | Consists of number counting, object counting, addition and subtraction operation. |

By conducting a review towards the similar application above, it help in identifying certain functionalities as the future enhancement and some of the functionalities can be used as the reference in developing the Mathfun mobile application.

Identifying the similar systems is relatively imperative as to help developer in improving the system functionality, as well as the design, which can lead a high acceptance from the user.

3. Methodology and School

Rational Unified Process (RUP) have been selected to be employed as the methodology used in developing this application. The MathFun mobile application system is required to design and develop with focus on essential elements and functionality, which might require changes simultaneously. Therefore, RUP methodology is suitable software development methodology as it allows the capability to adapt to changes in requirement throughout the development life cycle whereby resolving the project risks. (TatvaSoft, 2015)
The design and development occurred in the collaboration with the students and the teaching staff from the Special Children Society of Ampang (SCSOA) Learning Center. Field study experiments (actual devices) have been use to evaluate the application and mixed method of quantitative and qualitative analysis are used to achieve the outcome.

3 dyscalculia children and 3 teaching staff participated in this study. Table 4 shows the characters of the participate children.

|           | 1st user | 2nd user | 3rd user |
|-----------|----------|----------|----------|
| Age       | 6 years  | 7 years  | 10 years |
| Dyslexia severity level | Severe | Moderate | Moderate |
| Time to complete using the application | 15-20 mins | 10-15 mins | 10-15 mins |
| Clarification needed | Yes | No | No |

The teaching staffs are involved in this study in order to get more view and understanding towards the environment in which the children function in and the difficulties they encounter everyday in their learning process.

### 4. Design choices

In designing the Mathfun mobile application, Calculic model (figure 1) have been used in guiding the development of the application where it guide the developers towards the crucial component needed to be implemented in the design.
4.1. Application Design & features

The application is structured around 2 sections, which are learning, and exercise where in learning section there are categories, which are addition, subtraction, multiplication and discussion. The goal of this learning section is to support and improve the children learning process towards the basic mathematical logic through identification of the basic equations and symbol. Dyscalculia children often confuse with mathematical symbols and find it difficult to identify it therefore leads towards difficulty for them to complete math problems or understanding the concepts.

The main purpose of the learning sections is to help the children in understanding and familiarized with the symbols, which are commonly used in the mathematical domain. The exercise sections are designed towards the children needs and capabilities. The exercise section have the potential in motivating the children to increase their involvement with the application thus lead to the achievement of the application goal.

Table 5 shows the checklist of the component implement inside the design (figure 2) of the MathFun apps. For example for the font component based on the research it has identified that san serif font and roman style is suitable for learning disability children in improving their readability [6]. Therefore fonts, which fall under those categories, are used in the development of the MathFun Apps.

| No | Factors          | Components                      | Implementation |
|----|------------------|---------------------------------|---------------|
| 1  | Instructional    | Objective                       | ✔             |
| 2  |                   | Example                         | ✔             |
| 3  |                   | Practice                        | ✔             |
| 4  |                   | Error Correction & Feedback     | ✔             |
| 5  |                   | Progress Monitoring             | ✔             |
| 6  |                   | Language                        | ✔             |
| 7  | Personal         | Motivation                      |               |
| 8  |                   | Navigation                      | ✔             |
| 9  |                   | Color                           | ✔             |
| 10 |                   | Layout                          | ✔             |
| 11 |                   | Image                           | ✔             |
| 12 |                   | Video                           | ✔             |
| 13 |                   | Sound                           | ✔             |
| 14 |                   | Speech                          | NIL           |
| 15 | Environment      | Content error & Bias            | ✔             |
5. Results
The usability testing was done through observation and distribution of survey forms. System Usability Scale (SUS) have been used for this testing activity. Table 5 shows the results on the usability testing conducted to Dyscalculia children.

| Table 6: Result of Usability Testing (Dyscalculia Preschoolers) |
|---------------------------------------------------------------|
| Questions                                                      | Agree (%) | Disagree (%) |
| Q1 I think that I would like to use this System frequently     | 100       | 0            |
| Q2 I thought the system was easy to use                        | 100       | 0            |
| Q3 I could easily access the various menu option               | 100       | 0            |
| Q4 It was fun to use!                                          | 100       | 0            |
| Q5 Messages were always understandable                         | 95        | 5            |
| Q6 I was well supported by help options                        | 86        | 14           |
| Q7 The next step in my task was always clear                   | 90        | 10           |
| Q8 I likes the overall look and feel                           | 96        | 4            |

Good responses received from the Dyscalculia preschoolers where the children enjoy the application and agree that the application is attractive. The children able to use the application with minimal interruption from their teacher and they understand the components included inside the design of the MathFun apps. Form the observation done during the testing with the children, majority of dyscalculia preschoolers show keen interest in exploring the application. The children also willing to use the application in the class rather than learning it through the cards, which they are using now in the class.

Table 7 shows the responses from the teacher side after using the MathFun apps. Several comments where given by the teachers where the teachers have suggested some improvement towards the design such as the tooltips design, adding the statistics report for better monitoring done and layout for the placement of the math symbol.

| Table 7: Result of Usability Testing (Teachers) |
|------------------------------------------------|
| Questions                                      | Agree (%) | Disagree (%) |
| Q1 I think the apps is helpful                 | 100       | 0            |
| Q2 I’m willing to use the MathFun apps in class| 100       | 0            |
| Q3 I could easily access the various menu option| 100       | 0            |
| Q4 I likes the overall look and feel           | 80        | 20           |

Both teachers and children agree that the MathFun application is easy to use, match with the preschoolers needs and it improves the learning capabilities of the preschoolers. The MathFun apps also increase the interest of the preschoolers in learning math in a more fun approach.

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