THE FEATURES OF MOBILE APP DESIGN MODEL FROM DYSCALCULIA CHILDREN PERSONAL FACTOR

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ABSTRACT

Learning disabilities (LD) is a term that describes specific kinds of learning problem. LD affects how the people understand, remember and respond to information. The most common LD are including Dyslexia, Dyscalculia and Dysgraphia. Dyslexia is difficulties in reading, Dyscalculia refer to difficulties in math and Dysgraphia is difficulties in writing. Nowadays, mobile learning is widely used in special educational practice. Hence, Dyscalculia children should utilize the mobile or tablet devices as supportive learning tools to support their learning. However, currently there are inadequate studies on mobile app design model for mobile app designers and developers in designing and developing mobile app for Dyscalculia children. Thus, the aim of this study is to develop mobile app design model called Calculic Model that includes 3 factors which are personal, instructional and environment. The purpose of this paper is to report on the features under personal factor that relates to the cognitive of Dyscalculia children. The interview sessions were conducted with Dyscalculia practitioners involving teachers, pediatric and educational psychology. This has resulted in identifying the features of each component under the personal factor. Later the development of the Calculic Model will be based on the components and features that have been identified through interview session.

Keywords: Dyscalculia, Learning Disability, Mobile App, Model.

INTRODUCTION

According to the Ministry of Education Malaysia (2016) 689 pre-school children are enrolled in special education integration program for learning disability (LD) category. Meanwhile, there are 29,739 primary school children and 23,185 pupils in secondary school that have enrolled in the same program in year 2016. Social Welfare Department Malaysia has reported that 129, 550 people are registered as LD in year 2015. In Malaysia, Social welfare department has categorized Dyslexia, Dyscalculia and Dysgraphia under LD group. Research found out that Dyscalculia frequently co-occur with Dyslexia and Dysgraphia (Chinn & Ashcroft, 2017). Nowadays, mobile devices are
widely used in educational practice. Thus, LD children should take this advantage and utilize the mobile device as supportive learning tools. Nagavalli & Juliet (2015), reported that assistive technology such as mobile apps can be utilized to help Dyscalculia children perform in classroom and empower them to independently learn. Moreover, research by Mohd Ariffin, Abd Halim, & Ab Aziz (2017), reported that Dyscalculia children show positive improvement when they learn through mobile app.

In spite of an expanded enthusiasm for mobile learning, it is surprising that so minimal research has really been conducted on the mobile app design model for Dyscalculia children in instructing and adapting, particularly from the viewpoints of mobile app designers and developers. Recent study demonstrated that there is constrain of concentration on mobile app design model for LD children especially Dyscalculia. Currently, there are one million mobile app offer in market on Android and IOS operating system (Ok, Kim, Kang, & Bryant, 2016). However, the practitioners, for example, teachers and parents face challenges in choosing suitable mobile app for LD children (Weng & Taber-Doughty, 2015). In this manner, the designers and developers of mobile app are absence of direction to design and develop mobile app especially for teaching and learning for LD children (Draper Rodriguez, Strnadova, & Cumming, 2014). Thus, most of the mobile app for LD children are poorly designed (Papadakis, Kalogiannakis, & Zaranis, 2017). According to Cumming, Strnav, & Singh (2014), the mobile app designers and developers should follow the model and guideline from the researchers and teachers in order to design and develop the appropriate mobile app for LD children.

Besides that, it is crucial to identify the factors that affect Dyscalculia children in math learning. In this study, the personal factor is the factor that relates with the cognitive of Dyscalculia children. The cognitive skills play a critical role in math learning. Abd Halim, K Sugathan & Mohd Ariffin (2017) have proposed that Dyscalculia children have major difficulties in memory, visual & spatial processing and numeric processing speed. Thus, the proposed features in Calculic Model should be able to address their difficulties in term of their cognitive skills in order to help them in learning.

Hence, the objective of this research is to develop mobile app design model called Calculic Model. Besides that, the interview session with Dyscalculia practitioners involved teachers, pediatrician and educational psychology to identifying the features of each component under personal factor. This paper is structured as follows: section 1 the introduction, section 2 the literature review, section 3 the methodology, section 4 the results and discussion and section 5 the conclusion and future work.
LITERATURE REVIEW

Dyscalculia

According to American Psychiatric Association (2013), Dyscalculia is a particular learning issue that is portrayed by weaknesses in learning essential number facts, preparing numerical magnitudes and performing math operation. Cognitive investigations of Dyscalculia children demonstrate that although it regularly co-occurs with other disabilities, for example, Dyslexia and Dysgraphia, it can likewise happen in learners with no other disability (Laurillard, 2016). Research by Yen et al. (2017), found that possible indicators of Dyscalculia are numeric issues, spatial issues, memory issues and measure issue. Price & Ansari (2013), estimated that 3% - 6% of people have been perceived with numerical issue. The Table 1 shows the signs of the Dyscalculia children by Price & Ansari (2013).

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arithmetic</td>
<td>- Have trouble in remembering the number fact</td>
</tr>
<tr>
<td></td>
<td>- Have issues with basic math operation</td>
</tr>
<tr>
<td>Number processing</td>
<td>- Have issue in linked between the symbol and the word</td>
</tr>
<tr>
<td></td>
<td>- Have issue in number sequence</td>
</tr>
<tr>
<td>Non-numerical</td>
<td>- Have issue in size of shape (eg. big &amp; small, short &amp; long)</td>
</tr>
<tr>
<td>Deficit</td>
<td>- Have difficulty in direction (eg. left &amp; right)</td>
</tr>
</tbody>
</table>

Cognitive of Dyscalculia Children

As mentioned before, the personal factor is connection to the cognitive of Dyscalculia children. As indicated by Verdine, Irwin, Golinkoff, & Hirsh-Pasek (2014), it is critical to distinguish the cognitive of Dyscalculia children before outlining and building up any instructional application. It is imperative to recognize the cognitive of Dyscalculia children and creating appropriate approach from their cognitive aspect (Verdine et al., 2014). In term of cognitive aptitudes, the real challenges of Dyscalculia children are working memory (Menon, 2016), visual & spatial processing (Szucs & Goswami, 2013) and numeric processing speed (Käser et al., 2013).

Working memory is the capacity to keep up and process objective important data (Cowan & Powell, 2014). Many studies have proposed that working memory is relevant to mathematical development and mathematics difficulties (Cowan & Powell, 2014). Besides that, the Dyscalculia children have major difficulties in learning math because they have short term memory (Borg, Lantz, & Gulliksen, 2014). Hence, they will
experience difficulties in recalling number, the strategies use in math problem solving and easily losses place in calculation (Chinn & Ashcroft, 2017).

The visual and spatial processing is the capacity to process approaching visual stimuli, to comprehend the spatial connection between object and to visualize the picture (Fias, Menon, & Szucs, 2013). Research by Toffalini, Giofrè, & Cornoldi (2017), reported that Dyscalculia children is described by a general weaknesses in visual spatial capacities including visual spatial issue and visual perception. The Dyscalculia children have constrained visual-spatial limit (Karagiannakis, Baccaglini-Frank, & Papadatos, 2014). As indicated by Rapin (2016), deficiency of visual and spatial processing can delicate to trouble in understand number. Other than that, the Dyscalculia children experience issues to imagine the thing. Subsequently, they will experience issues in math operation that include translating, trouble in putting number in the number line and confusing the math symbols.

The numeric processing speed is the capacity to process the numeric data to perform the assignment rapidly and precisely (Shin & Bryant, 2015). The Dyscalculia children have difficulties in basic numerical processing (Raddatz, Kuhn, Holling, Moll, & Dobel, 2016). Shin & Bryant (2015) found out that the Dyscalculia children take longer time to solve math problem compared to the normal children. The Dyscalculia children deficit in subitizing and list, magnitude comparison, arrangement of number line and reading and writing numbers (Raddatz et al., 2016).

**Proposed Calculic Model**

It is important to identify factors that can affect Dyscalculia children in learning math before designing and developing a model. The Calculic model has 3 factors which are personal factor, instructional factor and environment factor. The Calculic model is used by mobile app designers and developers as a guideline in designing and developing mobile app for Dyscalculia children. The Figure 1 illustrated the proposed Calculic Model for personal factor.
The Calculic Model has proposed 9 components under personal factor which are motivation, navigation, font, color, layout, image, video, sound and speech. Hence, study conducted by Abd Halim, Mohd Ariffin & K Sugathan (2017) have supported that all the components under Personal factor is important for Dyscalculia children in learning. Moreover, the interview session was conducted with Dyscalculia practitioner to identify the suitable features for each of the components that appropriate for Dyscalculia children in learning.

**METHODOLOGY**

An interview session was conducted with Dyscalculia practitioners that involved teachers, pediatrician and educational psychology in order to identifying the features for each component in personal factor. The proposed features should be appropriate for Dyscalculia children in order to support their learning. The interview session was conducted to gather information about Dyscalculia children, the appropriate method to teach them, and how to design an effective mobile app for Dyscalculia.

**Participants**

Five Dyscalculia practitioners were recruited. Thus, the number of Dyscalculia practitioner in Malaysia is very limited. All the participants have more than 5 years of experiences in handling Dyscalculia children. The details of the participants are shown in Table 2.
Table 2  
Details of Participants

<table>
<thead>
<tr>
<th>Participant ID</th>
<th>Profession</th>
<th>Years of Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Educational psychology</td>
<td>17 years</td>
</tr>
<tr>
<td>P2</td>
<td>Pediatrician</td>
<td>15 years</td>
</tr>
<tr>
<td>P3</td>
<td>Teacher</td>
<td>7 years</td>
</tr>
<tr>
<td>P4</td>
<td>Teacher</td>
<td>6 years</td>
</tr>
<tr>
<td>P5</td>
<td>Teacher</td>
<td>7 years</td>
</tr>
</tbody>
</table>

**Instruments**

The author conducted face to face semi structured interview with P2, P3, P4 & P5. Meanwhile, the interview session with P1 was conducted via telephone. Each interview took between 45 minutes to 80 minutes. Participants were asked about: (1) their experience in handling Dyscalculia children; (2) to describe how they teach the Dyscalculia children and (3) their perspective on each of the components in the Calculic Model. The main questions in the interview guide comprised of:

1. What are the issues that Dyscalculia faced during learning process?
2. What are the suitable features for each component?
3. How can each of the components help Dyscalculia children in Math learning?

All of the components were probed with more specific questions and in depth discussion during interviews to understand the features of each component for Dyscalculia children during learning through mobile app and how to design for each component.

The data from the interview session were transcribed verbatim with consent. The data were analyzed to find the important of personal factor in math learning, the suitable features for each component and how can each of the components help Dyscalculia children in learning. The author used Atlas TI software in assist her in data analyzation.

**RESULTS & DISCUSSION**

Dyscalculia children are different from normal children. Thus, the learning style of Dyscalculia children is different with normal children. It is vital to identify the characteristic of Dyscalculia children and suitable teaching and learning approach to suite with their disability. As mentioned before, Dyscalculia is a LD that is related to math. Based on the research, usually Dyscalculia always co-occur with Dyslexia and Dysgraphia.
Personal Factor

Based on the interview session with Dyscalculia practitioners that involved educational psychology, pediatrician and teachers, they think that it is crucial to identify the characteristic of Dyscalculia children before designing any material to Dyscalculia children. In this study, the personal factor is linked to the cognitive of Dyscalculia children. As mentioned earlier, the Dyscalculia children have issue in the cognitive skill include memory, visual & spatial processing and processing speed.

According to P1 & P2, Dyscalculia children have short term memory. They will problem in remembering the sequence of the number and the connection between the symbol and the word (eg. 1=one). Besides that, according to P3, P4 & P5, Dyscalculia children usually have issue with their math exercise. They take longer time to complete math operation and they always not confidence with their answer.

Based on the interview session, all the participants have mentioned about the issues that Dyscalculia children faced in learning. Hence, all the issues related to the cognitive of Dyscalculia children are related with memory, spatial and visual processing and numeric processing speed. In addition, the proposed features should be able to address their major difficulties in term of cognitive skills.

The Features of Calculic Model

Based on the interview session, all the participant agreed that the components come from literature review could support Dyscalculia in learning. Thus, this study aimed to explore Dyscalculia practitioner’s point of view on how to design the effective mobile app that suite Dyscalculia children. Table 3 shows the summary of features for each component in Calculic Model:

<table>
<thead>
<tr>
<th>Component</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Motivation</td>
<td>Provide level.</td>
</tr>
<tr>
<td>2. Navigation</td>
<td>Simple navigation, more on symbol.</td>
</tr>
<tr>
<td>3. Font</td>
<td>Clear and precise, avoid color font.</td>
</tr>
<tr>
<td>4. Color</td>
<td>Background color should be soft color.</td>
</tr>
<tr>
<td>5. Layout</td>
<td>Simple. Avoid crowded word and image.</td>
</tr>
<tr>
<td>6. Image</td>
<td>Use real object. Avoid cartoon image during learning process.</td>
</tr>
<tr>
<td>7. Video</td>
<td>Provide video to explain such as subtract operation.</td>
</tr>
<tr>
<td>8. Sound</td>
<td>Use clapping sound. Avoid use discourage sound effect.</td>
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</table>
Majority of the participants agreed that motivation is the important component consistent with the previous study by Alamri & Tyler-Wood (2016). An effective mobile app should provide a support for users’ engagement during learning process. Interaction during learning process is important because it is a factor that affects children’s learning and motivation to learn. All the participants have mentioned about on provide the level of difficulty to easy, medium and hard is one of the ways that can motivate Dyscalculia children. The author proposed that the mobile app should provide the level of difficulties and rewards to motivate Dyscalculia children.

All the participants mentioned that the navigation features should be simple, have a help button, back and next button as suggested by Ok et al. (2016). They proposed that to use more on symbol and less word because Dyscalculia children understand the symbol better than the longer word. The appropriate navigations are in straightforward manner and consistent. Thus, the effective navigation is when the children use the mobile app with minimal adult assistance.

Moreover, Dyscalculia children also have difficulty in reading. Thus, the font presentation is an important component because the font can influence their reading performance and understanding on the word. Majority of the participants agreed that the font used should be sans serif consistent with the previous study by Rello & Baeza-Yates (2013). Hence, the participants have mentioned that the size of the font should be at least 12 point and avoid the colored font. Black color font is the most suitable.

Majority of the participants agreed that color is important in learning. Color can influence the learning process such as to keep focus, stimulate brain and straighten the memory as suggested by Kumi, Conway, Limayem, & Goyal (2013). It was predominantly agreed that the color used should be in soft color because bright color can distract Dyscalculia children in focusing during learning. The participants also suggested to avoiding using many colors.

The presentation style is very important because inappropriate presentation layout can be confusing particularly when the texts are written too close. Majority of the participants agreed that to use clear, simple and consistent layout design so that Dyscalculia children can navigate the app easier consistent with Kokkalia & Drigas (2016). Hence, the participants have proposed that the layout design should avoid the cramping material, use short text and use numbering or bullet point.

Furthermore, a study by Bryant, Shin, & Bryant (2015), has supported that the usage of image to provide a better understanding for Dyscalculia children. It was predominantly agreed that the usage of image in the mobile app can help Dyscalculia children in learning. Hence, the participants have mentioned that to avoid the cartoon image and use the real object such as human hands or the object that they are familiar with such as the stationery consistent with study conducted by Mohd Ariffin, Abd Halim & Ab Aziz (2017). Hence, the participants suggested that the background image in the learning
section should be in square shape and the symbol of math is written in the square shape as similar with their math exercise book.

Majority of the participants have agreed that a video should be used in order to make Dyscalculia understand the math concept consistent with Shin & Bryant (2015). The participants have proposed that video with audio is crucial in showing the example of the exercise and to provide step-by-step instructional support. Additionally, the participants have mentioned that it is better to provide a short video in the mobile app for teaching because Dyscalculia children usually have issues to understand math operation.

The sound component is a crucial component in the mobile app. The participants mentioned that the sound can maintain students’ concentration and keep engaging with the learning as suggested by Daud & Abas (2013). Hence, the participants proposed that the encouraging sound such as hand clapping can encourage and motivate them in learning. However, the participants proposed to avoid discouraging sound such as alarm when they choose the wrong answer because Dyscalculia children is emotionally sensitive towards discouraging sounds and speeches.

Besides that, a speech component is important for LD students and gives a greater learning effect. Majority of the participants have mentioned that the speech is important in educating Dyscalculia children through mobile app consistent with Weng & Taber-Doughty (2015). The participants proposed that the speech should be in slow pace so that the Dyscalculia children can understand. The participants also suggested that to use encouraging speech to motivate Dyscalculia children in learning.

Based on the interview session, the features of each component under Personal factors were identified. Hence, the features will be included in the proposed Calculic Model. Figure 2 shows the proposed features of Calculic Model for Personal Factor.
As mentioned before, the Calculic Model will be used by mobile app designers and developers in designing and developing mobile app for Dyscalculia children. Based on Figure 2, the proposed features that come from the interview session have been included in the Calculic Model. Later, the proposed Calculic Model will be verified by mobile app designers and developers.

**CONCLUSION & FUTURE WORK**

This paper presented the development of the mobile app design model for Dyscalculia children called Calculic Model that focuses on the Personal factor which is related to the cognitive of Dyscalculia children. The Calculic Model is for mobile app designers and developers to design and develop an appropriate mobile app for Dyscalculia children in Malaysia. An interview session was conducted with Dyscalculia practitioners that involved educational psychology, pediatric and teachers to identify the features of each component under personal factor. As a result, the features of each of the components were identified and will be included in the proposed Calculic Model. For the future work, the proposed Calculic Model will be verified by the mobile app designers and developers. Later, the mobile app will be designed and developed based on the Calculic Model.

**REFERENCES**


