Criteria and Guideline for Dyslexic Intervention Games

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***Abstract*—The utilization of game-based interventions is growing as a result of technological advancements, and it has shown to be effective in the treatment of dyslexia and other medical conditions. Games are typically viewed as activities having the essential components of challenge, incentive, and reward. Games were originally created for pleasure, and they can make dyslexic teaching and learning more enjoyable and exciting. Although there are numerous applications available for treating dyslexic children, the inclusion of games and their standards in those applications has not yet been established. Therefore, there is a need for a standard design guideline to be formulated in establishing a guideline for designing and developing games specifically for dyslexic children. This article proposes a design guideline for dyslexic intervention games. Two methods have been employed which are interviews and systematic literature reviews (SLR) to discover the characteristics of dyslexic games. The first set of the criteria was developed through interviews with the stakeholders who are directly associated with dyslexic children. Scopus, the ACM digital library, EBSCO-host, Wiley, and Web of Science (WOS) are the five primary databases used in SLR. 50 articles out of the 551 that were early screened from the five primary databases are qualified to be studied based on the criteria. Only 23 publications could be selected for the study after further screening, which led to the creation of a second set of criteria. These two sets of criteria are thoroughly analyzed, combined, and formulated as a guideline which comprises of four main categories; device and platform, interface, game features, and gameplay. The guideline consists of guidance to be used for designing and developing Dyslexic therapy games with the purpose of assisting Dyslexic children to read. The guideline is believed to be beneficial to many parties especially the educational game developers, therapists, and educationist who are dealing with intervention for Dyslexic children. This study is aligned and significant to Sustainable Development Goals (SDG) three and four, Good Health and Well-being and Quality Education respectively.**

Keywords*—*Dyslexic therapy games; game-based intervention; specific learning disorder; guideline for dyslexia games; dyslexia intervention

I. Introduction

Dyslexia refers to specific learning disorder (SLD) that involves difficulty in reading due to problems identifying speech sounds and learning how they relate to letters. It is listed as a mental disorder in the International Classification of Mental Disorders and the Diagnostic and Statistical Manual of Mental Disorders [1]. It resulted from an unexpected phonological deficit [2]. In other words, children with dyslexia have low ability in decoding and spelling. Often a dyslexic child will have trouble connecting the sound made by a specific letter or deciphering the sounds of all the letters together that form a word. Dyslexia have increasingly been found to be the most common learning disability accounting up to 80% of the learning-disabled population in general [3].

As of 2020, it is reported that between 5 to 20% of the world population struggled to read due to dyslexia [4]. In 2017, the Dyslexia Association of Malaysia reported 10% of the school age children in Malaysia were affected by the disorder. The percentage shows an increase from 2014 in which 53,685 students with learning disabilities have been involved in formal education and from that total, 0.03% or 1,681 students have been involved in the dyslexia classroom programme [5]. Earlier study conducted by Socio-economic and Environmental Research Institute of Penang has identified 9.4% of children in Grade One elementary schools in Penang as having learning difficulties, and 92.3% of these children were found to have severe reading disabilities [6]. It is one dyslexic case in every 20 students, compared to one down-syndrome case in every 600 people or one spastic case in every 700 people [7].

Despite the emphasis on literacy difficulties, dyslexia would appear to include a wide range of symptoms including poor short-term memory, dyscalculia, visual impairment, speech disorders, and poor motor control as well as emotional difficulties such as poor self-esteem, clinical depression, chronic anxiety and conduct disorders. The deficits in these keystone academic skills lead to poor academic achievement and they tended to lag far behind in age and intellectual ability from their peers. The impact can change at different stages in a person's life. It can seriously affect a person's self-esteem [8]. Dyslexia students sometimes feel dumb, frustrated, lonely, humiliated, and academically less competent than they really are. They may get very frustrated and are at risk of developing mental health problems such as anxiety and depression. Despite all these, dyslexia are not related to intelligence or lack of desire to learn.

Although dyslexia are typically thought of as learning difficulty with educational consequences, there is increasing evidence that dyslexia are also associated with health difficulties. Auto immune disorders, allergies, autism and schizophrenia are common amongst families where there are learning disabilities [9]. Furthermore, [10] observed that dyslexic children with the most severe symptoms of fatty acid deficiency (rough skin, dry skin and hair) have the most severe reading, spelling and short-term memory difficulties.

There is lack of consensus on how dyslexia should be diagnosed or treated. One systematic review [11] revealed that traditional special educational methods have limited impact on dyslexic children. Improvements through intensive reading interventions yield small to moderate effects overtime, and there appears to be a subset of 25% of problem readers who do not respond to special education. In the absence of satisfactory remediation through traditional special educational methods, there have been several alternative treatments offered for dyslexia. These include biofeedback, hypnotherapy, music therapy, visual occlusion therapy, the neural organization chiropractic technique, primary reflex therapy and Dyslexia Dyspraxia Attention Treatment (DDAT) exercises.

Past studies on dyslexia[12]–[15] utilized games, either for identification or intervention purposes, as discussed further in Chapter 2. Games add more fun and excitement to teaching and learning. Quite a few games have been developed as an alternative treatment for dyslexia. These include the board games (e.g. Zingo Sight Words, Scrabble Junior, Brainbox ABC, Monopoly Junior and Alphabet Lotto) as well as the online or digital games that run either on IOS or Android or both platforms (e.g. Draw Something, Hanging with Friends, Anagram Scramble, ABCya, Chicktionary, Boogle Bash, Knoword and Word Whomp). Different strategies are used in these games such as draw out a given word, spell a complex word, create ambiguous word to puzzle others, make out words from a given set of letters, find word while beating the time allotted, and complete words by conjecture based on the word's definition and first letter.

Designing games for the dyslexic needs careful consideration on their special needs in order to maximize their learning experience and overcome their difficulties. Several criteria for designing and developing an effective game for dyslexia intervention have been discussed in the literature, however, they are yet to be formalized into a standard guideline. To date, very limited number of standard guidelines exists and none of these focus specifically on games [16]–[18].

The absence of systematic guideline in designing and developing therapy games for dyslexic children is key issue to be solved in this study. To date, very few systematic guidelines have been developed. The [17] guidelines focus on early detection of dyslexia and is not meant for therapy. Whereas the [18] guidelines focus on learning reading but their emphasis is on user interaction with the application, i.e., how to design interfaces that are affective for the dyslexics. The guideline excludes important game elements such as goals, rewards, challenge and feedback. The author [16] developed a guideline for dyslexic games; however, the coverage is limited to user interface aspects of the games. Many other criteria discussed in the literature are not yet formalized into a guideline and thus, the process of designing and developing therapy games for dyslexia is time consuming as the developers need to gather and analyse the criteria from various sources.

Considering the addressed issues, this article aims to identify the criteria and formalize the guideline to be used in the design of dyslexic games. This will serve as a reference that would be beneficial for the developers of games or tools for dyslexic children.

II. Dyslexia and Intervention

The current state of dyslexia research can be characterized by the distinction of scientists in groups of protagonists of a visual versus a phonological/auditory deficit on the one hand and in groups of protagonists of a low, basic level versus a higher-level deficit on the other hand. A lot of contradictory results and theories posed the question about specificity and homogeneity of different deficits in dyslexic individuals. The model of [19] provides an integration of perceptive and cognitive deficits based on a common temporal processing deficit, which can be analyzed on a low, basic level and/or on a higher complex level of performance. Over the last 35 years, there has been a great deal of research focused on finding the most effective methods for treating dyslexia. This body of knowledge is complex, in part because although all individuals with dyslexia have a similar problem namely, difficulty in reading, they have heterogeneous characteristics, and depending on the child's developmental level, the demands of reading and the required skills are quite different [20].

The paper [21] suggests that difficulties in literacy acquisition for dyslexics are due to lack of phonological awareness, problems to recognize words and understand spelling rules, visual errors in spelling, letter and word confusion with similar-sounding words and omissions of words, parts of words and individual letters and sounds. In other words, their literacy skills are at word-level reading and spelling [22]. The dyslexics have difficulties in identifying phonemes and the exchanging of letters occurs very often during the spelling process; they also often mixed-up the letters of 'b-d', 'u-n', 'm-w', 'g-q', 'p-q', and 'b-p' [7], [23]. Evidence of their great difficulties in writing, poor skill of spelling, oral and written vocabulary and also weak in arranging the content of the compositions is also found in [24]. Besides, previous studies also found that children with dyslexia are significantly slower at naming colours, digits and letters, thus suggesting that children with dyslexia have persistent, and unexpectedly severe problems in naming speed for any stimuli [25].

The study [7] summarizes the difficulties in spelling, reading and writing faced by most dyslexic children as in Table I.

TABLE I. Problems Faced by Dyslexic Children

Problem	Description
Spell	Confusion in identifying letters such as: • m – w; y – g – j; u – n; m – n; c – e; p – q; h – n; b – d Confusion in the letter sound such as: • t – h; f – v; s –h; r – l
Read	Reversal in the word such as: • Batu – tuba • Gula – lagu Reversal in the sentence such as: • Pada masa yang sama – dapa masa yang masa Confusion between Malay and English word such as: • Jam – jem; cat – cat
Write	Difficulty holding a pencil; cannot write according to the line provided; tends to write words fads.

At a basic level of spelling, learning to represent sounds with letters requires a two-way mapping between phonology and written symbols, and it is here that difficulties will first be encountered by children with phonological deficits [26]. They need to acquire knowledge of the relationship between sounds and letters which requires them to be familiar with phonological representations and the correspondence between phoneme and grapheme. In the next step, they need to segment the target word into its salient sounds and then represent these sequentially with symbols [26]. What makes this exacerbated is the fact that spelling, unlike reading, is difficult to use context. In her study, [27] found a significant difference in the nature of the spelling errors in dyslexic children compared with a control group. They made 'phonetically unacceptable' errors that may not be recognized as the word because of a lack of phonetic similarity. This implies that the dyslexic children may have not developed phonological representation but use letter naming strategies to spell phonologically regular words.

Regarding reading, [28] suggests that for sight word reading to develop, learners must acquire and apply knowledge of the alphabetic system. According to [29], lexical processing, or the ability to recognize words quickly and accurately, is a symbol of skilled reading. In the context of Malay language, a study by [30] reveals both syllable awareness and phoneme blending are significant predictors of word recognition; when the readers have inefficient syllable segmentation, oversimplification of syllables, insufficient grapheme-phoneme knowledge and inefficient phonemic code assembly they will make errors in reading.

A. Dyslexia Interventions

Various intervention methods or treatments have been used to manage the literacy and cognitive abilities for children with dyslexia [31]. Most research used experimental designs [32]–[34]. There were a few studies that applied multimedia training in their intervention program. The researches [35] and [33] utilised computer-assisted training while [36] used video games in their remedial intervention. The study [37] adopted Magnocellular deficit theory in their treatment plan. A few studies employed multisensory approach [33], [38]–[42]. This approach uses graphics and strong colors to make associations between shape, letters, words and numbers that relate to the same topic, and involves techniques for linking eyes, ears, voice, and hand movements to symbolic learning. The approach taken is to try and engage as many sensory receptors in the learning process as possible, since it is argued that on many occasions, children with learning difficulties appear to have stronger sensory receptors over their non-dyslexic peers.

The majority of the studies targeted language or literacy components such as writing skills, reading skills, word and alphabet mastery as the outcome of the study [32], [33], [39], [40]. Many also carried out intervention or training based on specific impaired cognitive function such as visual-motor intervention and working memory training [35], [37], [38], [43], [44]. In other words, they have chosen a specific difficulty to be treated in their intervention.

To date, there are limited modules or intervention programmes being conducted in Malaysia for children with dyslexia. In fact, there is currently no standardized module for dyslexia class in Malaysian public school [31]. Traditional methods in teaching these children to overcome their difficulties in the classrooms were found not to be encouraging and were not successful in overcoming their difficulties in reading [40]. Thus, traditional methods have a limited impact on dyslexic children [11], [45].

B. Digital Game-Based Interventions

Recent decades have witnessed the increasing use of digital interventions with game-like components. Initially developed for entertainment, a ''game'' is generally considered to be an activity with the key features of challenge, motivation, and reward. Digital game-based interventions have been found to have practical effects in addressing the main barriers of access and engagement in the healthcare domain, particularly for the young [46]. Evidence from neuropsychological research further suggests the therapeutic value of digital game-based interventions in depression therapy. Positive game-playing experiences are claimed to have triggered the release of hormones such as endorphins and striatal dopamine that are responsible for feelings of pleasure and well-being [47]. Interventions using games have also been used in therapy or rehabilitation sessions of various other illnesses such as brain injury [48], cerebral palsy [49] and upper limb injury [50].

Past studies utilized games for diagnosis or early detection of dyslexia [17], [51]–[53] as well as for intervention [12]–[14], [54]–[58]. Other studies [56], [59] use gamification approach by utilizing some game elements (such as scores or rewards) in non-game context or the so-called application which ranges from desktop, mobile and web-based applications.

As evidenced in [55] and [60], games for dyslexia often implement a collection of activities that are connected by a common visual theme and can be played independently of each other. On the other hand, a smaller number of games are built around a rich narrative in which the student progresses through a story by solving language-related activities. For example, iLearnRW [13] draws together these two alternatives and provides a common interface and metaphor for the visualization of learning progress. The game is built around characters rather than a fixed story; although there is no guarantee for infinite re-playability, this has improved player's engagement. Each character in the game represents a group of language difficulties that the student will practice every time he/she initiates an activity related to them. Following an initial interaction with a new character, the student earns that character as a friend, who is displayed on a social network-like interface. The design of iLearnRW also considered the need for personalized intervention as some students learn faster than the others or prefer playing sessions at different length.

C. Existing Guideline

The study [17] derived a set of guidelines to design an optimal tablet game for 5-year-old children. The guidelines, called DYSL-X, focus on early detection of dyslexia and was used to develop Diesel-X, a game about a robot dog character named Diesel, which must fight against a gang of criminal cats. Diesel-X contains three games, which require players to know letters. However, there is no further information about the validation DYSL-X. The author [18] proposed an affective

interaction design (IxD) model to facilitate reading for the dyslexics. Their study emphasized on the need to use proper interface when designing an application for the dyslexics, by taking into account the affective attributes of the dyslexic children. In [16] proposed a guideline for dyslexic game design which focused on user interface aspects, i.e., usage of font, colour, navigation, consistency, interaction and game type. Recent studies [16], [52], [53], [61]–[64] revealed multiple criteria which are further analysed and formalized into the guideline developed throughout this study. The detailed criteria from individual studies are presented in Section IV.

III. METHODOLOGY

Due to its suitability and compatibility with the scope of study, a Design Science Research methodology [65] is adapted in designing the research framework. Research methodology is divided into four main phases; awareness of problems, identification of criteria, formulation of game guideline, and evaluation as illustrated in Fig. 1.

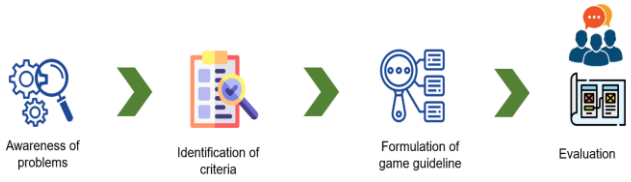

Fig. 1. Research Methodology.

A. Awareness of Problems

The first stage of conducting this study is about identifying issues and problems that lead to the formulation of solutions. Issues and problems are identified through content study and personal communications involving stakeholders in treating Dyslexic children. The absence of systematic guideline in designing and developing therapy games for Dyslexic children is key issue to be solved in this study.

B. Identification of Criteria

To identify the game criteria, combination of systematic interview and Systematic Literature Review (SLR) have been employed. Interview has been conducted involving eleven respondents among teachers and students at Dyslexia Incubator, School of Computing, UUM. Respondents involved are among the content experts, five teachers, and potential users who are the children diagnosed with Dyslexia.

SLR is conducted by adopting PRISMA approach in conducting SLR [66]. This study has focused on five main databases which are Scopus, ACM digital library, EBSCOhost, Wiley, and Web of Science (WOS). Four main processes that have been carried out in the searching process are identification, screening, eligibility, and data extraction and analysis as shown in Fig. 2.

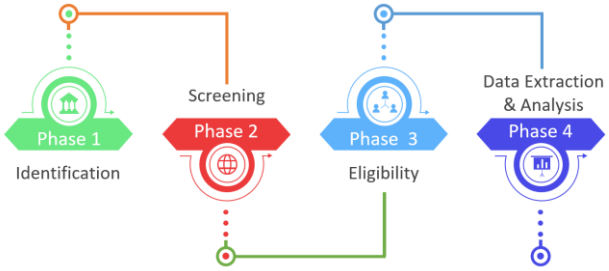

Fig. 2. Four Main Stages of Reviewing Literatures.

1) Identification: The first phase is about determining the keywords to be used for searching. In this context, keywords related to reading disabilities and the affected group, which are the children are basically relied on. The use of game intervention in treating the affected age group are also used in the searching. All keywords that have been used specifically for the database involved are listed in Table II.

TABLE II. KEYWORDS AND SEARCHING INFORMATION STRATEGY

Databases	Keywords used
Scopus	TITLE-ABS-KEY ((dyslexia OR ("reading disabilities" AND (child* OR kid))) AND (game OR "game intervention"))
ACM	[[Publication Title: dyslexia] OR [[Publication Title: "reading disabilities"] AND [[Publication Title: child*] OR [Publication Title: kid]]]] AND [[Publication Title: game] OR [Publication Title: "game intervention"]] OR [[Abstract: dyslexia] OR [[Abstract: "reading disabilities"] AND [[Abstract: child*] OR [Abstract: kid]]]] AND [[Abstract: game] OR [Abstract: "game intervention"]] OR [[Keywords: dyslexia] OR [[Keywords: "reading disabilities"] AND [[Keywords: child*] OR [Keywords: kid]]]] AND [[Keywords: game] OR [Keywords: "game intervention"]]
EBSCOhost	TI ((dyslexia OR ("reading disabilities" AND (child* OR kid))) AND (game OR "game intervention")) OR AB ((dyslexia OR ("reading disabilities" AND (child* OR kid))) AND (game OR "game intervention"))
Wiley	"(dyslexia OR ("reading disabilities" AND (child* or kid))) AND (game OR "game intervention")" in Title, Abstract and keyword
WOS	TS=((dyslexia OR ("reading disabilities" AND (child* OR kid))) AND (game OR "game intervention"))

2) Screening: For screening of the relevant articles, several conditions for inclusion and exclusion have been defined. Type of literature, language, and subject area are among the criteria that have been included. Criteria and its eligibility terms are defined in Table III.

TABLE III. THE INCLUSION AND EXCLUSION CRITERIA

Criterion	Eligibility	Exclusion
Literature type	Journal (research articles)	Journals (systematic review), book series, book, chapter in book, conference proceeding
Language	English	Non-English
Subject Area / Categories	Computer Science	Other than Computer Science

The searching also focused on literatures with empirical data such as journal articles, research articles, and review articles. To prevent difficulties of translation, only English articles are included. For relevance, articles with related to the focus are selected which are related to the use of intervention games that involve children with reading difficulties. For this phase, 10 articles have been removed.

3) Eligibility: The main focus of this phase is to identify the eligible articles to be included in the study based on the criteria explained earlier. To achieve this, the identified articles are reviewed and thoroughly analyzed. Focus is given on the targeted objectives. To identify the details, abstracts will be reviewed before the articles will be analyzed thoroughly. Fig. 3 illustrates the processes involved by adapting PRISMA method.

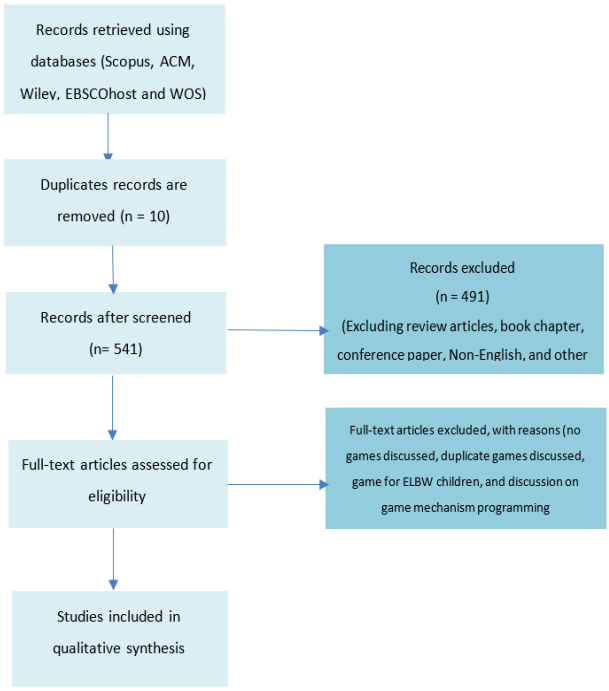

Fig. 3. Adaption of PRISMA Approach in Selecting the Articles.

From the process, there are 551 articles have been early screened from five main databases to be further reviewed. From this total article, there are 10 duplicate articles and have been removed for the next process. 541 articles were further screened based on the relevancy to the criteria. However, only 50 articles are eligible to be analyzed. After further screening, there are only 23 articles which are significant to be included in the study.

4) Data extraction and analysis: This phase is focusing on extracting and analyzing key details from the 23 articles that have been chosen. Various types of data are extracted from these articles. They are proponents of the criteria, year of study, game title, and the criteria of the game. The list of the extracted criteria is covered in findings section of Section IV. Deliverables of this phase are two sets of the criteria for Dyslexic game.

C. Formulation of Game Guideline

List of criteria gathered from SLR and interview are thoroughly analyzed and compared in formulating the guideline. Set one of the criteria is extracted from SLR, while set two of the criteria is gathered from interview. Processes involved in formulating the guideline are shown in Fig. 4.

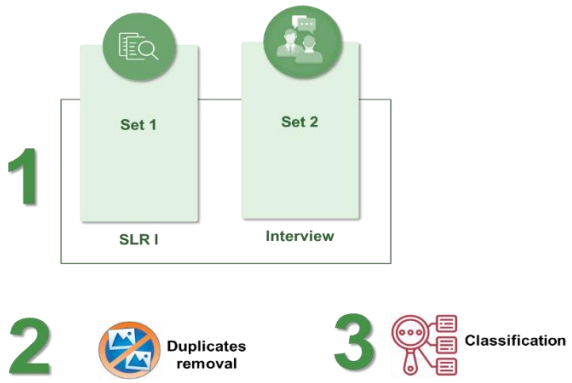

Fig. 4. Processes Involved in Formulating the Guideline.

Second process involved the removal of duplicates of the criteria by analyzing similarities exist in both sets. Removal also involved for cases when some criteria are using different words but are referring to the same thing. The last step is classification, where all criteria are mapped into four main categories; device and platform, interface, game feature, and gameplay. The outcome of these processes is covered in Section IV.

D. Evaluation

To ensure that the proposed guideline is correctly formulated and meets its specification, both verification and validation are conducted in evaluating the proposed guideline. For verification, expert review has been conducted involving five experts from different areas; game development experts, educationist, and counsellors. For validating the guideline, a prototype of Dyslexic game, namely *DysRedia* is developed. The outcome of the evaluation and its detail discussions are covered in Section IV.

IV. THE PROPOSED GUIDELINE

The proposed guideline is formulated based on the two sets of criteria gathered and extracted from systematic interview and the existing studies through systematic literature review as

explained in Section III. The first set of criteria are extracted from 23 related articles from SLR. The extracted criteria are sorted based on its publication years. The listed criteria are carefully analyzed by focusing on similarity of the criteria proposed by its proponents. Duplicates are removed. The criteria are then classified into four main categories: device and platform, interface, features, and gameplay. There are five, eleven, thirteen, and sixteen criteria classified into four categories respectively.

Second set of the criteria are gathered from interview session involving teachers and students. Table IV depicts 30 criteria gathered from interview that have been categorized into four main categories.

TABLE IV. CLASSIFIED CRITERIA GATHERED FROM INTERVIEW

Category	Criteria	
Device & platform	1. Mobile app 2. Tablet	3. Touch-based
Interface	1. Simple interface 2. Font & background: F8 (white font, red background)	3. Font type: comic 4. Font size: 16 5. Small caps
Features	1. Audio 2. Video 3. Still picture 4. Animation	5. Background music 6. Letter with phonic 7. Letter arrangement: keyboard design 8. Attractive images
Gameplay	1. Exercises 2. Different difficulty levels 3. Competition 4. Hints 5. Help 6. Tutorial 7. Rewards, more rewards at higher levels	8. Scoreboard 9. Replay 10. Auditory feedback 11. Different categories 12. Real images 13. More exercise in the same difficulty level 14. Levels arranged alphabetically

There are three, five, eight, and fourteen criteria have been classified into four categories respectively. Fig. 5 shows number of criteria and its category that have been successfully classified.

Fig. 5. Number of Criteria Acquired from Two Method and Classified into Four Categories.

These two sets of criteria are then combined based on its category. For Device and Platform, five criteria from SLR and three criteria from interview are combined producing only five criteria, as three of them are redundant and have been removed. The final five criteria are shown in Fig. 6.

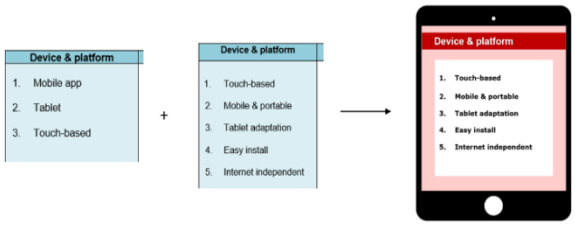

Fig. 6. Criteria for Device and Platform Category.

For Game Features category, eleven and five criteria identified from SLR and interview respectively have been combined and produced a guideline of 13 criteria by removing three redundant criteria. The final thirteen criteria are shown in Fig. 7.

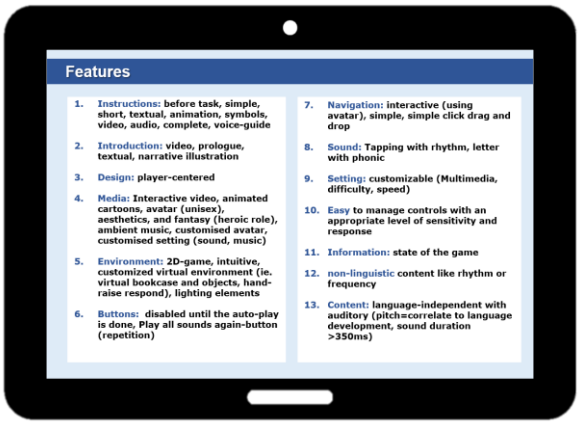

Fig. 7. Criteria for Game Features Category.

For Interface category, combination of 13 and eight criteria identified from SLR and interview respectively, have produced a final set of eleven criteria. Ten redundant criteria have been removed. Terms referring to the same criteria such as ‘small caps’ suggested by interview and ‘lower case’ suggested by SLR are combined. We decided to use ‘lower case’ in the criteria as suggested by most of the proponents. A final version of eleven criteria for Interface category is shown in Table V.

For Gameplay category, sixteen and fourteen criteria identified from SLR and interview are combined and produced a final set of 18 criteria. Twelve redundant criteria have been removed. Criteria using different terms but are referring to the same criteria are also removed. A proposed guideline for Dyslexic intervention games comprising of all final combined criteria are illustrated in Fig. 8.

TABLE V. CRITERIA FOR INTERFACE CATEGORY

Interface	
1. Simple interface	2. Font size: 16, 18, 18-26, minimum font size of 14 points
3. Font colour: grey scale in font (10%), text in black using a mono-spaced, dark colour on light background (Suggest cream color background, white font, red background)	4. Font type: lower case, Arial typeface, typeface Courier, font style Verdana, OpenDyslexic font, Helvetica, Comic san)
5. Background: grey scale in the bg (90%) crème/black color pairs, text in black on creme background, plain background, brilliant/bright colors	6. Layout: Fixed , Unobstructed views, playful, line spacing (1.4), paragraph spacing (2), column width (77 character/line), column width not wider than 60 characters per line, consistent, character spacing (+7%), Child friendly color (unique to induce positive emotion) and shape (round)
7. Figures: simple geometric	8. Icon: 3D
9. Graphic/visual: simple, consistent, appealing, easy to interpret, large and touchable, attractive, searh-like, non-related linguistic, letter arrangement: keyboard design, real images	10. Character: cute, children friendly
11. Fantasy-themed setting	

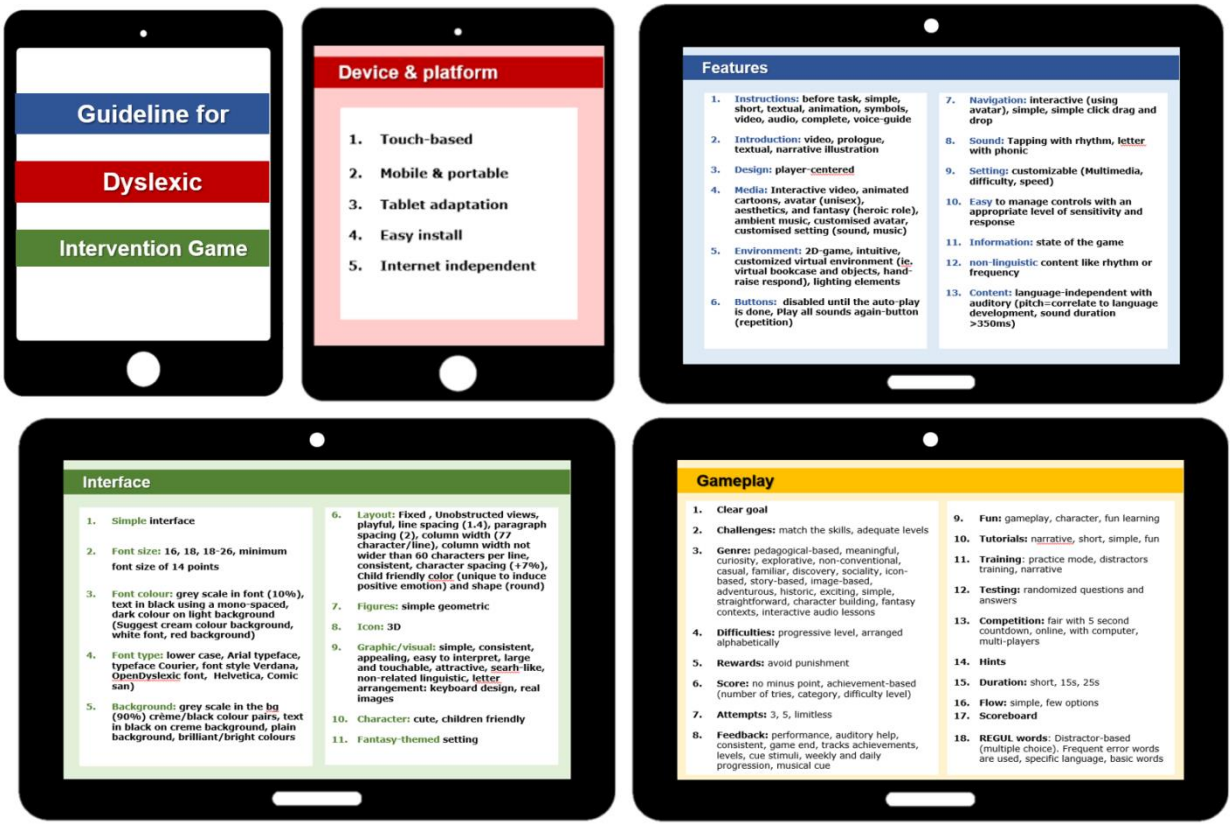

Fig. 8. The Proposed Guideline.

1) Evaluation of the proposed guideline: The proposed guideline has been evaluated through two methods; expert review and prototyping. Verification is conducted before validation. Five experts were involved in verifying the proposed models in ensuring that the proposed guideline confirms its specification. Table VI listed five experts involved in reviewing the proposed guideline.

TABLE VI. EXPERTS BACKGROUND

Expert	**Field of expertise**	**Qualification & designation**	**Years of experience**
Exp1	Special education	Dyslexia teacher	2 years
Exp2	Counselling	Trainee	4 years
Exp3	Computer system and network	PhD, Lecturer	More than 20 years
Exp4	Interaction design	PhD, Lecturer	20 years
Exp5	Counselling	Trainee	4 years

There are eight components that have been used in reviewing the proposed guidelines; clarity, visibility, comprehensive, evolutionary, flexibility, accuracy, understandability, and effectiveness. Clarity is meant to evaluate whether the guideline is clearly presented. There are four constructs used to measure the clarity of the guidelines; (C1)-the whole design guideline for Dyslexic game is clearly presented, (C2)-the categories in the design guideline for Dyslexic game are defined clearly, (C3)-the elements in the design guideline for Dyslexic game are defined clearly, and (C4)-all relations between the categories and elements are clearly presented. For measuring visibility, three constructs have been used; (V1)-the design guideline for Dyslexic game is visible to be followed, (V2)-the guides involved can be followed easily, and (V3)-the design guideline for Dyslexic game can be a guide by developers to solve related tasks of design and development. Fig. 9 shows the mean score for each construct for clarity, visibility, comprehensive, and evolutionary.

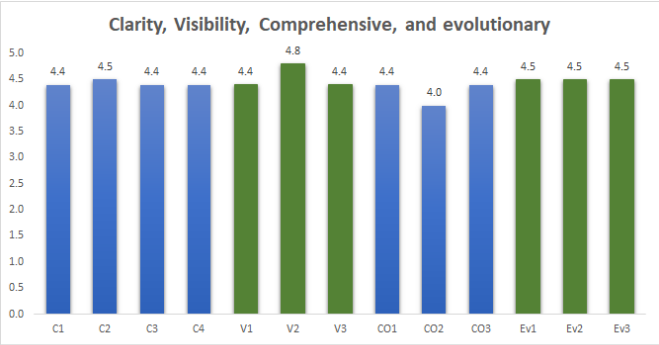

Fig. 9. Expert's Review on Clarity, Visibility, Comprehensive and Evolutionary.

To measure the completeness of the guideline, three constructs have been used; (CO1)-the whole design guideline for Dyslexic game is defined completely, (CO2)-the design guideline for Dyslexic game covers all related elements, and (CO3)-the relations between the categories and elements are sufficient. While for measuring the ability of the guideline to evolve, three constructs are used; (Ev1)-the design guideline for Dyslexic game is dynamic, (Ev2)-the design guideline for Dyslexic game allows additional factors in the future, and (Ev3)-the design guideline for Dyslexic game provides opportunity for improvements.

Mean score for all constructs in measuring clarity, visibility, comprehensive, and evolutionary are considered high (more than 2.5). It can be concluded that all experts agreed that the proposed guideline is clear, visible, complete, and able to evolve. Another four aspects used in measuring the guidelines are flexibility, accuracy, understandability, and effectiveness. There are three, four, two, and three constructs used for each aspect respectively. Constructs used to measure flexibility are; (F1)-the design guideline for Dyslexic game is flexible to be edited, (F2)-the design guideline for Dyslexic game is adaptive to changes, and (F3)-the design guideline for Dyslexic game is generalizable enough to be applied for other related tasks.

While for measuring how accurate the guideline is, two constructs are used; (A1)-the design guideline for Dyslexic game is presented correctly and (A2)-all categories and elements factors are labelled correctly. Four constructs are used to measure understandability; (U1)-the whole design guideline for Dyslexic game is easy to understand, (U2)-The label of each category is understandable, (U3)-the label of each factor is understandable, and (U4)-adhering to the design guideline for Dyslexic game is easy. The last aspect is the efficiency of the proposed guideline. There are three constructs used; (*Ef*1)-the design guideline for Dyslexic game can guide in the development of engaging Dyslexic games, (*Ef*2)-adhering to the design guideline for Dyslexic game will improve the engagement of Dyslexic games, and (*Ef*3)-adhering to the design guideline for Dyslexic game will improve usability in Dyslexic games. Fig. 10 shows the mean score for each construct for flexibility, accuracy, understandability, and effectiveness.

Fig. 10. Expert's Review on Flexibility, Accuracy, Understandability and Effectiveness.

Mean score for all constructs in measuring flexibility, accuracy, understandability, and effectiveness are considered high (more than 4.0). It can be concluded that all experts agreed that the proposed guideline is accurate, flexible, can be easily understood, and effective. Experts have also given their overall review of the guideline. They are particular on visual aspects of the guideline especially on interface elements as suggested by Expert 1, Expert 4, and Expert 2.

E3	:	*Customizable font size*
E1	:	*Font style: = use the written letter 'a' not 'a'*
E2, E5	:	*Font style = choices between capital letter and small case*

Font size is important element involving Dyslexic children. Three experts suggested font size to be customizable in the game. Expert 1 is consistent with what is proposed in the guideline on the font type, as San Serif font should be used. Expert 2 and 5 are also suggested that players should be given options to choose between capital letters or small letters to be used in the game. Other elements also attracted Expert's attention, for example background music (pleasant to children's ear) and hints (disclosing one letter). They prefer options to be given in turning on background music. While for hints, they suggested that hints only to be given when they win the game. Too many hints will discourage learning among players as suggested by Expert 1.

E1	:	*Background music= on/off button*
E1	:	*Gain hint through winning, they will keep use hint if too many hint*
E4	:	*The guideline should be printed in bigger size.*
E1	:	*Application Icon = attractive*

Experts are concerned about the look of the proposed guideline as well. They prefer the guideline to be printed in bigger size. However, the A4 size guideline is only printed for evaluation purpose. Since the guideline comprises of textual elements, Expert 1 also suggested the use of application icon which is more attractive.

Second phase of evaluation involved validation of the proposed guideline with the intention to check whether the proposed guideline meets the requirements and expectations. For validating purpose, prototyping method is used. A prototype of dyslexic game is developed, namely DysRedia by taking considerations the criteria listed in the proposed guideline. DysRedia is a proof of concept of the proposed guideline. Fig. 11 shows selected interfaces of DysRedia prototype.

Fig. 11. Selected Interfaces of DysRedia.

Version 1.0 of DysRedia has been demonstrated to two teachers and students at Dyslexia Incubator, School of Computing. 34 children had experienced playing and testing it. DysRedia has been improved by taking considerations of their responses and feedback. For example, letters were initially in upper case have been changed to lower case as shown in Fig. 12.

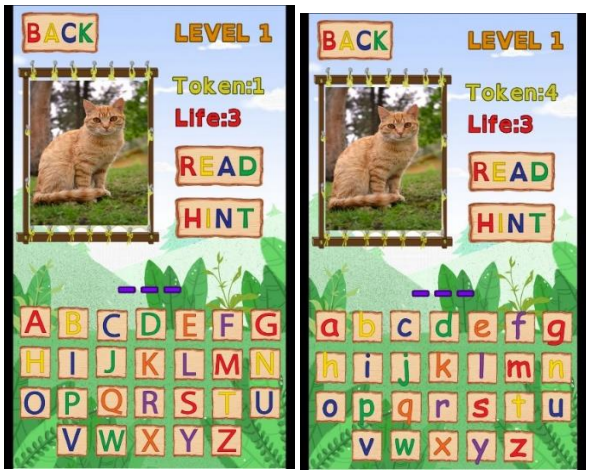

Fig. 12. The Improved Version of DysRedia.

V. Conclusion

A design guideline for Dyslexic Intervention Games has been successfully designed and evaluated. A significant contribution of this study is the criteria and guidelines for Dyslexic game which will benefit game developers, practitioners, and educationist who are directly involved with Dyslexic children. The proposed guideline can serve in assisting them in designing and developing game applications for dyslexic children.

This study also presented DysRedia, a game which is designed and developed based on the proposed design guideline as a proof of concept to the proposed design guideline. With high acceptance of the game, it is supported that the proposed design guideline is an appropriate design that follow gamification concept, friendly to target audience, and Dyslexic acceptance. The proposed criteria and guidelines can be adapted to other similar domains, such as special needs education therapy, particularly involving with Dyslexic children.

This study is aligned and significant to Sustainable Development Goals (SDG) three and four, Good Health and Well-being and Quality Education respectively. The outcome of this study could contribute in improving the reading ability among dyslexic children. Future works might consider different type of evaluation of the proposed guideline involving bigger audience of testers.

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