International Journal of Engineering & Technology, 7 (4.31) (2018) 168-174

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Exploring Design Guidelines of Tangible Interaction in Learning for Children with Dyslexia

Siti Nurliana Jamali[1*], Novia Admodisastro[2], Abdul Azim Abd Ghani[3], Sa'adah Hassan[4], Azrina Kamaruddin[5], Siti Suhaila Abdul Hamid[6]

Faculty of Computer Science and Information Technology,
University Putra Malaysia, Malaysia
**Corresponding author E-mail: gs45705@student.upm.edu.my*

Abstract

Tangible Interaction (TI) has shown many benefits in various situations for it provides more direct manipulations and haptic feedback. In addition, TI also provide a more enjoyable learning environment. Despite active research in TI, there is limited research on design learning, particularly associated with the TI for children with dyslexia. Current approaches are found to still depend on traditional multisensory teaching materials. However, some literatures argued that the use of traditional multisensory teaching materials used in the current teaching technique is less attractive, lack sense, offer no feedback such as sound and only rely heavily on the teacher. A preliminary study was conducted to understand better how TI works for children with dyslexia. The study is conducted by the research team using a semi-structured interview and observations with teachers who teach dyslexic children. In this paper, an investigation of the teaching materials and learning approaches used in the Dyslexia Association of Malaysia (DAM) learning centre to support children with dyslexia were studied and analysed. Finally, design guidelines are constructed and proposed based on the data obtained from the study conducted. The design guidelines will be adopted to develop a tangible interaction between the learning model and its prototype for children with dyslexia.

Keywords: *design guidelines; dyslexia; children; tangible interaction*

1. Introduction

Humans learn in various ways be it through cognitive, physical and emotional interaction with the external environment. With the aid of information technology, the interaction can be achieved using tangible interaction (TI) which allows the user to interact with digital information through the physical environment. TI allows the user to link between the physical world and the digital world with a physical object being linked to digital representations to convey a various range of information. TI has great potential to support children in a learning process that includes children with dyslexia [8, 11]. Children with dyslexia are prone to difficulty in language which affects their ability to acquire the reading, writing, speaking and listening skills. It is an impairment in the use of words including when the children learn a language such as the Malay language.

Recent studies showed that TI has unique characteristics which offer multiple learning modalities such as tactile, kinaesthetic, auditory, and visual. These learning modalities create multisensory experiences that are coherent and robust for dyslexic children [1]. The integration of various modalities has also shown greater effectiveness to enhance children's attention while learning [20, 24]. Nevertheless, the use of current traditional multisensory teaching materials such as flash cards and other similar materials have been found to be less attractive, offer insufficient senses, provide no feedback such as sound and rely heavily on the teacher. These limitations can be overcome by the integration of technology in teaching and learning. It has been argued that children with dyslexia can learn to read and write well with suitable technological intervention.

Therefore, in this paper, a preliminary study has been conducted to better understand the learning approaches that can be used with dyslexic children in relation to TI for designing TI learning model for children with dyslexia. The preliminary study uses the qualitative data from the author [21] who had conducted a study together with the Dyslexia Association of Malaysia (DAM) through semi-structured interviews and observations with experts and children with dyslexia.

The remainder of this paper is structured as follows. In Section 2, we present the background of the study. Next, in Section 3, the study methodology is described. In Section 4, the result and analysis of the findings are presented. In Section 5, we discuss the design guidelines in learning for children with dyslexia. The paper provides a conclusion in Section 6.

2. Background Study

This section describes the background study pertaining to children with dyslexia, TI for learning disability, and a review of several works related to this study.

2.1. Dyslexia

Dyslexia is a language disability, affecting reading and writing, speaking and listening. According to [5] dyslexia can be classified into six types of difficulties: difficulties in learning language, imbalances in intellectual abilities, lack of fluency when reading

Copyright © 2018 Authors. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

printed material, unable to write smoothly and accurately (difficulty in copying words from the blackboard or books), eyes become tired when focusing intensely on certain words and very limited concentration in terms of visual and hearing. Based on these different categories of difficulty, dyslexics can be categorized according to the sensory system, (1) Visual Dyslexia – refers to pupils who can see well but could not interpret or remember things seen. They also have trouble pronouncing a word that has a lot of syllables. (2) Auditory Dyslexia – refers to pupils having problems to distinguish similarities and differences between the sound heard, identifying each sound in words, blending sounds to make words, and dividing a word into syllables. Sometimes the children could hear the words, but some of the information is lost when the brain processes the sound and sounds may be fused, reversed or jumbled. Most dyslexics have the auditory dyslexia. (3) Visual-Auditory Dyslexia – pupils with difficulty using both senses, i.e., sight and hearing. The effect will pass through an interference in the process of receiving information through visual and auditory means. These impairments affect dyslexic children's self-esteem, they feel less accomplished and it resulted in them feeling less intelligent than they are supposed to be [13]. According to the International Dyslexia Association [26], these impairments of learning disabilities can be accomplished via multisensory method whereby it incorporates the use of visual, auditory and kinaesthetic sensories to improve memory and stimulate initiative in learning.

2.2. Tangible Interaction for Learning Disability

According to **[**7**]** children with learning difficulties can be supported by providing a richer, multisensory interaction to facilitate them in learning. Other researchers [17, 22, 27] have suggested that the teaching method for children with learning difficulties must include visual, auditory and kinaesthetic approaches. TI could aid the children with the appropriate resource materials, concrete examples, practical solutions (learning by doing) as well as organise supportive learning. In addition, [28] also mentioned TI can be accessible to children as well as assumed to be more natural or familiar for children with learning difficulties by reducing the value of participation on others. Another benefit of TI in aiding learning difficulties is to encourage children to perform tasks on their own. Besides that, TI is able to increase the children's confidence and lower the need to rely on others [22]. It is important to consider graphical representations, auditory and haptic feedback when designing TI for children with learning difficulties.

In addition, TI encourages exploratory interaction that is sufficiently flexible to include different levels of achievements as well as to let others take part according to their own capability. In [7] work, they have produced four design guidelines to develop an educational resource and learning approach for children with different learning difficulties: *kinaesthetic method*, *modes of representations*, *collaboration*, and *resources*. The TI approach that they proposed needs to comply with these four guidelines. Firstly, the kinaesthetic method consists of physical engagement such as moving, touching and manipulating. Secondly, the mode of representations is where children with learning difficulties prefer concrete examples in order to make them understand abstract ideas. Adding to that the children have a higher concentration on oral interaction as well as dynamic pictorial and lower number of text. The third is a collaboration between dyslexic children that encourages the forming of group work in order to provide support to one another and chance to observe others while considering individual expression. Lastly, to ensure each of the children would be able to have the equal opportunity to participate which caters to various needs and abilities of the children.

2.3. Related Works

There are several related works that discussed TI for children with dyslexia. The works have addressed different language processing skill difficulties (e.g., reading, phonology, spelling or writing), intended to support specific language (e.g., English, Spanish etc.) and using different types of tangible objects (e.g., 3D blocks, tabletop etc.). The works are discussed as follows:

The work in PhonoBlocks [2] has described a tangible user interface to a reading system that uses dynamic colour cues embedded in 3D tangible letters to provide additional decoding information and modalities for children aged 5-8 years old, who are having difficulty learning to decode English letter-sound pairs. The work has addressed several TI design guidelines in assisting dyslexic to read such as spatiality, various types of interaction modalities, and multiple ways of letter representation as well as structured procedures. PhonoBlocks allows concurrent use of visual, auditory as well as kinaesthetic or tactile approach in both physical and digital representations. It also focuses on the 3D design of tangible letters which facilitate dyslexic children to learn letter as a basis rather than words because they often struggling with letter-sound correspondences and mirror-letter.

Meanwhile, in I-BLOCKS [16], has provided support for linguistic scenario and construct sentences for children with dyslexia that children can control by allowing them to have interaction with the building block. The work also emphasises on the use of physicality of the children body movements through spatial and kinaesthetic approach as well as allows rich multisensory interaction.

Another work in Tiblo [18] the work helped in enhancing children motor skills whereby involves connecting and attaching the blocks tangibly. Children also could improve their social collaboration where each of them will have their own representations in terms of sound, and image they created and collaborate between one another. Besides that, Tiblo has greater significance impact where children can create storytelling and story building tools in collaborative ways. Tiblo provides limited support in letter-sound correspondences and mainly use to address reading difficulties. Tiblo provides training for dyslexic children on recognizing letter sound by incorporating multisensory approach such as auditory, visual, tactile and kinesthetic. Besides, audio is embedded in the Tiblo to offer feedback and increase children attention to letter sounds.

TraceIt [25] is developed to helps beginner level reader to read by using multisensory approach. This includes kinaesthetic movements by using their body movements. This program lets the children trace the letters using physical objects that interact to the program. The program also provides audio feedback when the children trace each alphabet. Besides that, a colour-based recognition is included to detect hand motion through tracked coloured objects.

Finally, Tactile Letters [9] is a multimodal tangible tabletop that comprises of texture cues to teach English alphabet sound to dyslexic children aged around 5 to 6 years old. The prototype is developed as an instrument to examine the role of texture cues for the children to learn the alphabets. Two set of tangible letters were designed with or without texture cues and each set is comprised of 24 pieces of letter cards. The children could choose to locate the 3D tangible letters or use the letter cards on the interactive tabletop. Each of the tangible letters produced audio feedback to the children whenever they provide a correct or incorrect connection with the 3D tangible letters. Also, the design guidelines emphasized in this work was on design spatiality which allows dyslexic children to decode and arrange the letters in their space environment. Besides that, multiple senses such as audio, visual and tactile were incorporated in the work.

3. Study Methodology

The preliminary study conducted in this work refers to [21] and it aims to investigate the teaching materials and learning approaches adopted the by the DAM to support dyslexic children in learning. Three experts were interviewed in the study [21]. The first expert was the President of DAM who has more than 30 years of experience in teaching children with dyslexia. While the second and third experts were the teachers in DAM, who have more than 5 years of experience. The thematic analysis method was used to classify themes or patterns found in a qualitative data. In the analyses process, we have adopted a procedure based on Braun and Clarke [4]. There are six phases taken while conducting the thematic analysis process

(1) Be familiar with the data- In the initial phase, the interview transcript was examined, and all emerging ideas were identified to familiarize ourselves with the data. Then the entire data re-examined and notes were made to obtain early impressions of the issue.

(2) Generate initial code- At this stage, the data was arranged in a significant and organised way. We also established the relevant data that was interesting and specifically addressed our research questions. We performed this process manually which involved reading and analysing the primary data using a marker pen and a pen along with a spreadsheet program.

(3) Search for themes- In this phase, we searched for themes by identifying certain patterns that were relevant and interesting in the data as well as research questions. According to [4] there was no other way to determine the themes as they would emerge from the data by their importance. For example, we have organised the types of learning activities that were undertaken during the teaching process, the characteristics of TI, the type of learning being performed, types of modalities and representations used in the learning in as illustrated in Figure 1.

(4) Review themes – At this stage, we reviewed the initial themes that were defined in the previous step by doing modifications to the relevant themes only. We used colour coding techniques to associate each theme. For example, we use different colours to differentiate the significant themes.

(5) Define themes – The phase aimed to determine the ending of the refinement process of the themes which emphasized the relationship between one theme to another. In this study, we developed a sub-theme for the characteristics of TI under the main theme of physical and digital representations whereby we included the use of 3D physical objects and textured objects which offered multimodal information. Another sub-themes that we defined was for multiple interaction modalities in which we included the tactile modality to benefit dyslexic children in learning letter shapes and phonology. We also described other important sub-themes which require dyslexic children to use their multiple senses such as auditory, visual, kinaesthetic and tactile to assist in reading acquisition in as presented in Figure 2.

(6) Writing up – The final stage was to determine our final analysis for the data extract and also to address the research questions. This report provided the data relevant to the themes, literature and research questions to provide a guide in performing the thematic analysis procedure.

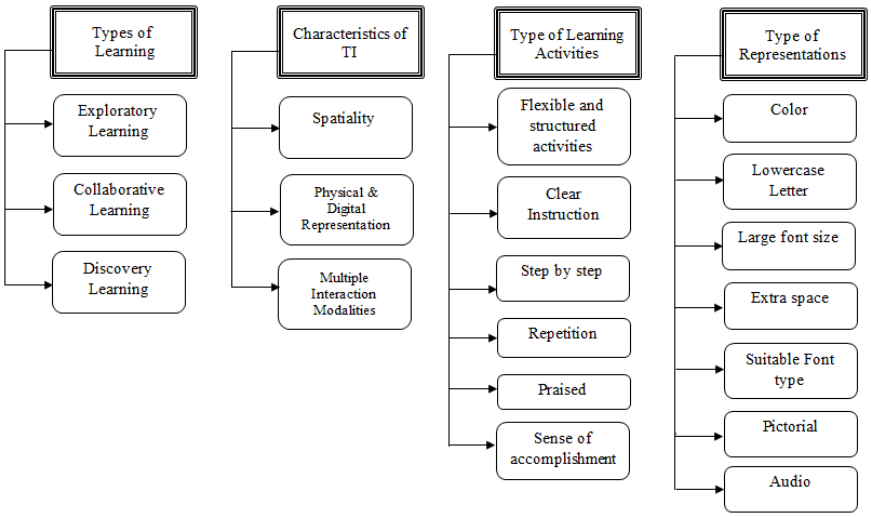

Fig. 1: Draft themes for searching patterns

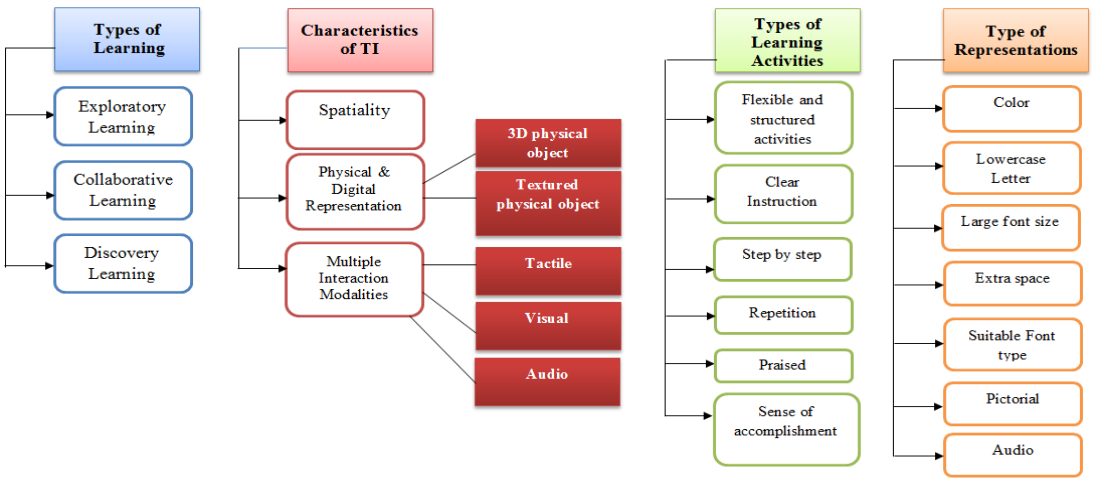

Fig. 2: The final thematic mapping with new sub-themes

3. Result and Analysis

We organised the results into four sections based on the themes we obtained from the thematic analysis:

3.1. Types of Learning

In this section, we identified the appropriate learning activity based on the data [21] that was used at the DAM for improving the reading, writing, spelling, and phonological skill of dyslexic children by incorporating exploratory learning activity. This exploratory activity included constructing sentences as well as identifying letters using the approach in the reading booklet, conventional tabletop, alphabet boards, flash card, bingo, dominoes and sorting block shapes as shown in Figure 3 and 4. For example, in the booklet activity, the teacher asked the students to find the letter in the first book with the number given at the corner of the book and students needed to find this on their own by searching the object in the second book. This study material adopted the Orton-Gillingham (OG) theory which claimed that kinaesthetic-tactile reinforcement of visual and auditory associations could correct the tendency of confusing similar letters and transposing the sequence of letters while reading and writing [19]. Besides that, the DAM also applied computer-based application like MyLexic [14] to teach the Malay language subject. The application provided audio and visual modalities which allowed the dyslexic students to recognise the letters, matching words with the correct pictures and listening to the sound of the letters. The statements below were the quotes from the expert:

"We used MyLexic application software for children with dyslexia in learning. The courseware is quite good, but it is installed on the desktop using a mouse. But the interaction is limited, and children with dyslexia were known to use all the senses when learning that require them to manipulate the tangible object. They also have a psychomotor problem which affects their body coordination such as jumping and gripping pencil. It would be great if there is a tangible interaction system that could aid the dyslexic children in learning."



Fig.3: Flashcards



Fig. 4: Basic sight word

Other essential study material revealed was using a snap card which was played by five people in a group. This study supports a collaborative learning activity whereby each of the students' needs to match the first letter of the picture shown on the card. The student who collected all correct matches needed to say 'snap' aloud and wins the game. The students must monitor and focus on each other's facial expressions to accomplish the task given to them and create shared spaces of collaborative connections. Furthermore, this activity allowed students to increase their visibility of other students' actions as well as improve communication between them and the teachers. Besides that, another activity used a stick with its end attached to a paper that contained words with consonant and vowel. This approach can improve the students' visual skills and could enhance their spelling skill. In addition, the approach provided playful learning where the teachers moved the wooden stick to the left and right, and the students must capture the words at a quick pace.

3.2. Characteristics of Tangible Interaction

We revealed the characteristics of TI in learning which could support dyslexic children to learn reading, spelling, and phonology. The observation which was conducted by [21], revealed the current study materials which incorporated spatiality such as using alphabet boards, bingo, dominoes, snap card and flash card as shown in Figure 5. For example, when the alphabet board was used, the teacher asked the students to spell words and the students would choose a letter from the board and placed the letter on the table. The teacher then instructed the students to select another consonant to spell other words. This encouraged the students to relate to the space which allowed them to arrange letters in order and inevitably involved their physical sensor. This activity helped dyslexic students to recognize alphabets and learn the sound of the letters effectively as well as strengthen their reading, spelling and writing skills.



Fig. 5: Alphabet board

When children learn to read, they will incorporate letters in spatial orders. The physical involvement in the space would allow hands-on interaction with the 2D or 3D letters. It was shown that TI has the potential to support them in acquiring the reading skill. For instance, children with dyslexia have a complication to manipulate sounds in speech and have difficulty learning the letters. The children could locate the 2D or 3D letters on the tangible tabletop, that could produce the sound of the letters and the 2D letters with the same spatial order would appear on the display screen. The associations between the letters and sounds needed to be consistent with the mapping of physical and digital representations. The use of tactile and kinaesthetic approach can enhance children attention and memory in learning [15]. Besides that, this approach adopted the theory of kinaesthetic which requires children to manipulate, organised and interpret the letters, flashcards, dominoes and block shapes that they have encountered through tactile (touch) or kinaesthetic (movement) sensors [12].

Dyslexic children learn well when they can perform body movements or use their hands and provide senses of touch. Writing and drawing also can be associated with physical activities. One common kinaesthetic teaching method used with dyslexic students is 'air writing' whereby students say a letter out loud while simultaneously writing it in the air **[**25**].** This activity can apply a tactile approach which is helpful for dyslexic children

in learning word sentences, construct letter shape and sound associations. For instance, in the Dominoes study material, students needed to match the initial part of the dominoes card that consisted of sentences with and ending sentences correctly.
According to one of the experts, "*The suitable font representation for children with dyslexia is using Sans serif font type explicitly in the learning content to avoid misunderstanding. For example, this type of letter 'a' was not being used in the teaching of dyslexic students since they are not familiar with and not being taught of that letter in the class. The use of font types like Comic Sans and Century Gothic would be perfect for dyslexic students because they already familiar with the letter shape of 'a'. In addition, the use of capital letter must be located at the beginning of the sentences and must avoid from using text bold as it will make dyslexic children have double visions on their eyes. Also, the content and letter representation must have extra space between words to avoid text crowding".*

3.3. Types of Learning Activities

Children with dyslexia require multisensory interventions that provide flexible learning methods [1]. In the DAM, they normally used conventional ways in which the tutor was required to teach the children using words and letters. By using TI intervention, it allowed various responses such as providing sounds or changing the colours of the letters. Besides that, by incorporating various access points of the physical objects, it could give the tutor and children flexibility to engage in a learning activity as well as allowing them to collaborate in finishing the task. They also required clear instruction and step by step routine work to complete the desired task. Children with dyslexia also need repetition activities which can strengthen their memory in executing the work.

3.4. Types of Representations

Colours play an essential for dyslexic students in their learning process. According to the experts, in current teaching approaches, different background colours are used in the reading activities. Colours can result in faster reading time for dyslexic students. Besides that, colour also can be applied to categorize the family words and used to distinguish syllables, sentences, and words. The use of colour overlay can significantly improve reading speed as well as reading comprehension. Dyslexic students tended to be familiar with lower case letters. They needed a large font size in order for them to read the words. Other than that, they determined the words by a family group such as 'ig', 'at', 'an', 'ug' and many more as shown in Figure 6. In fact, dyslexic students have difficulties reading bold letters and avoid uppercase letters. Based on the experts, the words needed to have extra spaces in between to avoid text crowding. Appropriate font types also have to be considered such as using Comic San Ms and Century Gothic [21]. This is due to the mental model of dyslexic students who are familiar with this alphabets pattern of 'a' which to them is supposed to represent a type of 'a'. The text must be presented in a large size font to catch their attention and make it easier for them to read the words.

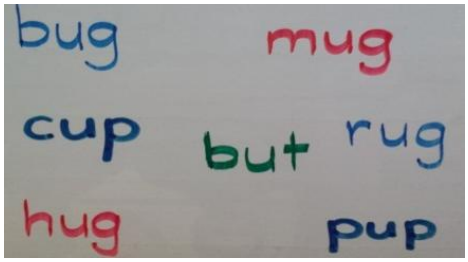

Fig. 6: Words by family group of 'ug'

Dyslexic students prefer to see information and visualize it using graphics, pictures and chart presentation. They need clear and colourful pictures in the presentation. According to the dual code theory [6], dyslexic students need verbal and non-verbal representations that will be processed using visual information such as diagrams, animations, and photographs. It is vital to use a clear picture that is colourful to capture dyslexic students' attention and enhance their perception as well as allowing them to learn a language in a fun way. The following quote was stated by the expert who said: *"Before entering the DAM, the student needs to be given an assessment question. We will look at their writing skill, spelling skill, their level of understanding after reading whether the student can comprehend all the given questions. Sometimes, we just use a picture and asked the student to name it, to spell it, to explain about it and to create a sentence from it. Once we identify their difficulties, we will be able to place the student in the appropriate class either beginner, intermediate, or advanced".*
Moreover, from the interview conducted by [21], the expert said three groups of family letters were introduced to the dyslexic children. The first group of letter was *'a', 'd', 'g' and 'q'*. The expert said that *"usually we will teach the dyslexic children to find patterns in the group of the letter".* For example, the the letter 'a'; if the letter has an upper stick it becomes the letter of 'd'and if the letter of '*g*'it has a tail on it and lastly, the letter of 'q' that has a lower stick on it. The second group of the letter is 'r', 'n', 'm', and 'h'. The expert said that the letter 'r' is half of the letter 'n' and the letter 'n' is half of the letter 'm'. Lastly, the letter 'h' has a upper stick on it. The third group of family letters is 'e', and 'c' which determines if the letter 'e' has a head unlike letter 'c'. In addition, this approach of learning family letters is crucial to be taught first to the dyslexic children because they have difficulty in differentiating the letters. The expert also mentioned, *"we want to make things simpler for the dyslexic children due to their disability to recognize letters and making the learning fun for them."*

4. Tangible Interaction Design Guidelines in Learning for Children with Dyslexia

From the thematic analysis we conducted, several design guidelines were categorized based on the four themes identified. The four design guidelines are *types of learning*, *characteristics of TI*, *types of learning activities* and *types of representations*.
The first design guideline is the type of learning which focuses on *exploratory*, *collaborative* and *discovery* learning. The e*xploratory learning* encourages children to examine and investigate the information and knowledge they received by exploring on their own. This technique promotes learning by allowing the dyslexic children to learn by doing. Also, TI offers fun learning and increase the basic motor skills of dyslexic children due to their nature of having difficulty with coordination such as object manipulation, movement, twisting, flipping, writing, as well as colouring. Next is *collaborative learning* which offers children to work together in a group in order to solve a problem as well as accomplish certain task. Usually, the children maybe work with more than two or more members to search for the answer, solutions and understand the tasks. TI also support this collaborative learning which encourages the dyslexic children to exchange objects with each other and improve their social interaction. This will allow them to have access to a shared representation so that the problem will be solved together and reduce cognitive load. The final design is *discovery learning* which focuses on the children's ability to participate in problems solving activities whereby the children discover the solutions based on their past experiences. This discovery learning promotes independent learning whereby most of the dyslexic children have relied heavily on the teacher and parents to perform the study.
The second design guideline is *characteristic of TI* such as *spatial, physical and digital representations*, and *multiple interaction modalities*. In developing TI, spatial representation played important roles which referred to the details that TI needed to embed in real space and users must make movement in real space

when interacting in the space environment. For example, in the flashcard learning activities, the students needed to construct the words by arranging the flashcards on the table. This activity involved movements and interactions with the object by performing the actions in the space.

Next, physical and digital representations consisted of 3D objects such as tactile letters and the incorporation of the use of textures to the physical objects. Since children with dyslexia require a multisensory approach to stimulate the brain and improve the learning, having this textured effect will enhance their learning. The example of this activity can be referred to in the alphabets board which enable dyslexic children to recognize alphabets and effectively learn the sound of letter as well as strengthen their reading, spelling and phonological skills. When children learn to read, they will incorporate letters in spatial orders. The physical involvement in the space would allow hands-on interaction with the 2D or 3D letters**.** Besides that, this approach adopted the theory of kinaesthetic which requires children to manipulate, organise, arrange and interpret the letters.

The following is the multiple interaction modalities which comprises tactile, visual and audio simulation. This activity enables children with dyslexia to have options of the type of interaction they wish to engage in during learning. The example of learning activity can be applied to this design guideline in the dominoes study material, where the students needed to match the initial part of the dominoes card that consisted of the beginning of a sentence and ends the sentences correctly. This activity can apply the tactile approach which could help in learning word sentences, construct letter shape and allow sounds associations for dyslexic children.

The third design guideline focuses on the type of learning activities to be incorporated into the TI system for children with dyslexia. *Flexible and structured activities* allow dyslexic children to apply a chosen learning activity based on the needs of individual children. The structured activities described the specific learning objectives such as play with purpose. The learning activities can include learning about living skills such as the month of the year and that also encourage their motor skills during learning. For example, the in the learning activity using wooden stick where the teacher moved the sticks, and the students need to spell the words on the stick.

Next is *clear instruction* which will allow dyslexic children to have clear, simple and unambiguous instructions in order to perform tasks such as to recognize words and to listen to the sound of the letter that corresponded with those words using the alphabet board and flashcards activities. Instruction activities are suitable for dyslexic children since they have difficulty in recognizing alphabets and sentences and they often struggled with familiar words when no pictures were given to them. Then, the *step by step* action allowed them to perform certain tasks such as arranging the letter to construct words.

Following that is the *repetition* activity in which dyslexic children may require more time and repetitions since their concentration time is lessened. As a result, they needed a very short learning session. For example, in learning activity using flashcards, the teacher may repeat the letters many times and pronounce the sound of the letter clearly to the students. Subsequently, *praises* will be embedded in the learning by giving the students a problem-solving activity, and once they have completed the task, their efforts would be acknowledged. The *praise* method will enhance the students' motivation to achieve the goals and make them feel good about their achievements. The learning activities associated the students performing the reading task using a booklet with rewards like spending time with friends and get to collect stars for their achievement once they finished.

The final design is the *sense of achievement* which refers to someone who has achieved something that s/he is proud of. For example, the students have completed the task where they are required to spell the letters and combine the letters to make them into words. This activity allows the children to be self-motivated and feel delighted with themselves.

The fourth design guideline is *types of representations* which encompasses *colours*. To dyslexic students, colours play an essential role in their learning. In the current teaching approach, the teachers use different background colours in the reading activity. The colours will determine the fastest reading time for dyslexic students. Besides, colours can also be applied to categorize the family words such as 'ig', 'up' and 'se' to enable the dyslexic students to distinguish syllables, sentences, and words. The use of colour overlays can significantly improve reading speed as well as reading comprehension.

Next is the text where dyslexic children encountered barriers because they can hardly read. The text must be presented in large sized fonts to catch their attention and allow them to read the words easily. Dyslexic children tend to prefer *lowercase letters*. They need *large font size* in order for them to read the words. In fact, dyslexic students have difficulty reading in bold letters and they tend to avoid uppercase letters. Also, the words need to have *extra spaces* in between. Appropriate *font types* also have to consider using *Comic San Ms* and *Century Gothic*. This is due to the mental model of dyslexic students who are familiar with the alphabet 'a' that is supposed to represent another version of the letter 'a'. For the *pictorial* type of representation, dyslexic children prefer to see information and visualize it using graphics, pictures and chart presentation. These pictorial representations need to have clear and colourful pictures in the presentation.

5. Conclusion

In this paper, we presented a preliminary study to obtain interesting patterns and emerging issues in evaluating the study material used in the DAM as well as the types of learning activities being performed. The primary data was obtained from the main researcher who performed a semi-structured interview study with dyslexia teachers in the DAM. The use of traditional multisensory approach in the DAM, for children with dyslexia have proven to be less attractive, lacking in sense, no feedback and rely heavily on the teachers in the teaching technique. Children with dyslexia learn better with the support of *sound*, pictorial, and phoneme of words in their learning activities. This will involve reading, spelling and listening skills. Thus, we identified several design guidelines that are categorised based on four themes. The four design guidelines are *types of learning*, *characteristics of TI*, *types of learning activities* and *types of representations*. Our next step is to develops a TI learning model based on the purposed design guidelines the children with dyslexia. The TI learning model is developed to facilitate the children with dyslexia in reading, spelling and phonology skills for the Malay language.

Acknowledgement

Special thanks to Dyslexia Association Malaysia (DAM) for great assistance in this research. We would also like to thank the university's ethics committee who approved our application to conduct this study, along with the GP-IPS/2016/9479000 grant awarded for funding the research work.

References

[1] Antle A. N., & Alyssa F. Wise, Getting down to details: using theories of cognition and learning to inform tangible user interface design interacting with computers, Vol.25, No.1,(2013), pp:1-20, available online: https://doi.org/10.1093/iwc/iws007, last visit:15.01.2018.

[2] Antle, A. N., Fan, M., & Cramer, E. S., "PhonoBlocks: a tangible system for supporting dyslexic children learning to read". Proceedings of the international conference on tangible, embedded and em-

bodied interaction, ACM, (2015), pp:533-538, available online: http://dx.doi.org/10.1145/2677199.2687897

[3] Avramidis, E., Bayliss, P., & Burden, R. (2000). Student teachers' attitudes towards the inclusion of children with special educational needs in the ordinary school. teaching and teacher education, Vol. 16, No.3, pp: 277-293, available online: https://doi.org/10.1016/S0742-051X(99)00062-1, last visit:10.02.2018

[4] Braun, V., & Clarke, V.," Using thematic analysis in psychology". Journal of qualitative research in psychology, Vol.3, No.2, (2006), pp.77-10, available online: https://www.tandfonline.com/doi/abs/10.1191/1478088706qp063oa, last visit: 07.06.2018

[5] British Dyslexia Association(1999). Assessing reading difficulties: a diagnostics and remedial approach. Windsor: NFER-Nelson

[6] Clark, J. M., & Paivio, A.: dual coding theory and education. Educational psychology review, Vol.3, No.3, (1991), pp:149-210, available online: https://doi.org/10.1007/BF01320076

[7] Falcao, T. P., & Price, S., "Informing design for tangible interaction: a case for children with learning difficulties", Proceedings of the 9th international conference on interaction design and children ACM, (2010), pp. 190-193,available online: http://dx. doi.org/10.1145/1810543.1810568

[8] Fan, M., Antle, A. N., & Cramer, E. S.,"Design rationale: opportunities and recommendations for tangible reading systems for children", Proceedings of the The 15th International Conference on Interaction Design and Children, ACM, (2016), pp. 101-112, available online: http://dx. doi.org/10.1145/1810543.1810568

[9] Fan, M., & Antle, A. N., "Tactile letters: a tangible tabletop with texture cues supporting alphabetic learning for dyslexic children", Proceedings. of the conference on tangible, embedded, and embodied interaction, ACM, (2015), pp. 673-678, available online: http://dx.doi.org/10.1145/2677199.2688806

[10] Gomez, C., Dyslexia in Malaysia International book of dyslexia: A guide to practice and resources, John Wiley & Sons, (2004), pp: 158-163.

[11] Hengeveld, B. J. (2011). Designing LinguaBytes: a tangible language learning system for non-or hardly speaking toddlers (Doctoral dissertation, Technische Universiteit Eindhoven).

[12] Kinesthetic Learning Strategies, (2017), Kinesthetic learning strategies for various subjects, available online: http://www.kinestheticlearningstrategies.com/kinesthetic-learning-strategies-for-various-subjects/

[13] Madeira, J., Silva, C., Marcelino, L., & Ferreira, P., "Assistive mobile applications for dyslexia", Proceedings of procedia computer science, Vol.64, (2015), pp: 417-424, available online: https://doi.org/10.1016/j.procs.2015.08.535

[14] Muhammad Haziq Lim Abdullah, Syariffanor Hisham, and Shahril Parumo.," MyLexics: an assistive courseware for dyslexic children to learn basic malay language", SIGACCESS Newsletter Issue 95, (2009), pp: 3–9, available online: http://doi.org/10.1145/1651259.1651260

[15] Minogue, J., & Jones, M. G., "Haptics in education: exploring an untapped sensory modality". SAGE Journal review of educational research, Vol.76, No.3, (2006), pp. 317-348, available online: https://doi.org/10.3102/00346543076003317, last visit: 05.06.2017

[16] Marti, P., & Lund, H. H. "Novel tangible interfaces for physical manipulation, conceptual constructions and action composition", Proceedings of the intelligent manipulation and grasping, Vol. (2004).

[17] Ndombo,M.,D., "An intelligent integrative assistive system for dyslexic learners". Journal of assistive technologies, Vol.7, No.3, (2013), pp.172–187, available online: https://www.emeraldinsight.com/doi/abs/10.1108/JAT-11-2012-0036, last visit: 20/06/2017

[18] Pandey, S., & Srivastava, S.,"Tiblo: a tangible learning aid for children with dyslexia". Proceedings of the conference on creativity and innovation in design. ACM (2011), pp:221-220, available online:http://dx.doi.org/10.1145/2079216.2079247

[19] Reid, G.: Dyslexia: A Practitioner's Handbook. John Wiley & Sons (2016),pp:1-23.

[20] Siti Zulaiha Ahmad, Nik Ludin Nik Noor Amalina Amirah, Mohd Ekhsan Hawa, Rosmani Arifah Fasha, and Ismail Mohd Hafiz., "Bijak membaca - applying phonic reading technique and multisensory approach with interactive multimedia for dyslexia children", CHUSER IEEE Colloquium on Humanities, Science and Engineering Research, (2012), pp: 554–559, available online:https://doi.org/10.1109/CHUSER.2012.6504375

[21] Siti Suhaila A. Hamid, Novia Admodisastro, , Azrina Kamaruddin, Noridayu Manshor, & Abdul Azim Abdul Ghani., "Informing design of an adaptive learning model for student with dyslexia: a preliminary study". Proceedings of the 3rd international conference on human-computer interaction and user experience in Indonesia, ACM, (2017), pp. 67-75, available online:

[22] http:// doi.org/10.1145/3077343.3107577

[23] Scruggs, T. E., & Mastropieri, M. A., "The construction of scientific knowledge by students with mild disabilities", Journal of special sducation, Vol. 28, No.3, (1994), pp. 307-321, available online:http://journals.sagepub.com/doi/abs/10.1177/002246699402800306, last visit : 16.03.2016

[24] Smythe, I., Everatt, J., & Salter, R., The International Book of Dyslexia: A Guide to Practice and Resources. John Wiley & Sons. (2005), pp:158-164.

[25] Subramaniam Vijayaletchumy, Vijay Kumar Mallan, and Che Mat Noor Hayati.," Multisenses explication activities module for dyslexic children in malaysia", Asian Social Science, Vol.9, No. 7, (2013), pp:241–267,available online: https://doi.org/10.5539/ass.v9n7p241

[26] Teh, T. T. L., Ng, K. H., & Parhizkar, B., "TraceIt: an air tracing reading tool for children with dyslexia". International Visual Informatics Conference Springer, Cham, Vol.9429, (2015), pp: 356-366, available online:https://doi.org/10.1007/978-3-319-25939-0_32

[27] The International Dyslexia Association" multisensory structured language teaching" 2000. Available online: https://dyslexiaida.org/multisensory-structured-language-teaching-fact-sheet/, last visit 02.05.2018

[28] Tittarelli, M., Marti, P., & Peppoloni, D., "Rapping dyslexia: learning rhythm, rhyme and flow in dyslexic children", Proceedings of the 8th nordic conference on human-computer interaction: fun, fast, foundational ACM, (2014), pp:865-870, available online:http://dx.doi.org/10.1145/2639189.2670181

[29] Zuckerman, O., Arida, S., & Resnick, M.," Extending tangible interfaces for education: digital montessori-inspired manipulatives", Proceedings of the SIGCHI conference on human factors in computing systems ACM, (2005), pp: 859-868, available online: http://dx.doi.org/10.1145/1054972.105509